

# AGRICULTURAL ENGINEERING

OCTOBER • 1955

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*In this Issue . . .*

**Development and Design Features of  
the Mounted Grain Drill**

**Measuring Lateral Pressures Exerted  
on Walls of Horizontal Silos**

**The Role of Farm Implement Lubricants  
as Engineering Design Aids**

**Automatic Machines Record Hydrologic  
Data for Expedient Reference**

**Daily and Seasonal Evapotranspiration  
Rates for Different Crops**

*ASAE Winter Meeting • Chicago, Ill., December 12 to 14*

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**THE JOURNAL OF THE  
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS**

# ALL NEW

# CASE

# "400"



SEND FOR THE FILMS  
THAT TELL THE STORY



"Building America's Finest Diesel" . . . a new sound slide film that presents dramatically in 28 minutes the remarkable way Case Diesels are produced . . . from the manufacture of engine parts with automatic machines that are uncanny in their precision and operation . . . right down to the extraordinary procedures of quality control, assembly and testing.

## Truly Amazing in Design ...without Peer in Performance

Yes, the all-new Case "400" stands as symbol of what advanced engineering can achieve . . . of how engineering vision transforms itself into practical reality . . . and brings farming of the future into beneficial focus today. Truly, the 4-plow "400" is just such a creation . . . one that is breath-taking in its two-tone beauty . . . and literally "out of this world" in functional features.

Take, for example, its all-new engines—Powrcel for Diesel fuel, Powrdyne for gasoline, LP gas or distillate—both with super strength throughout and electric-hardened five-bearing crankshafts. Then, there's the new Powr-Range transmission with eight speeds forward and two reverse for an unbroken transfer of power from a slow crawl to fast road travel . . . all supremely simple with one shift lever, one clutch, one gear-set plus a shift pattern that's so natural. Even more, there's Uni-Thrust "ball point" front suspension for easy manual or power steering . . . Duo-Valve hydraulics with limited down-pressure control to aid ground penetration . . . and operator comforts that defy adequate description.



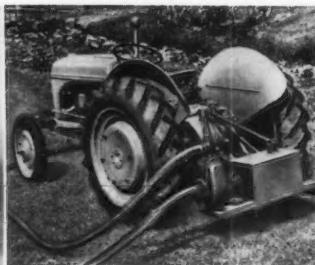
"The New Case '400' Tractor" . . . a sound, full-color, 10-minute motion picture of today's finest tractor in the 50 h.p. class . . . powerfully and indelibly portrays the advancement that Case engineering and research has made in its dedicated service to modern power farming. See your Case dealer about loan of these films or write the J. I. Case Co., Racine, Wis.



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Cultro, Inc.



TRANSPORT MIXER WAGON  
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**Specialized Implements sell better**

**with well-known, well-proved**

## **BLOOD BROTHERS P.T.O. Drive Lines**



TRAILER PUMPER  
The Gorman-Rupp Co.



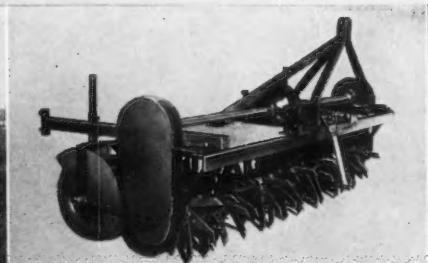
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Now that well-developed implements have mechanized *major* farm tasks, farmers want more and more *specialized* machines to speed other chores.

To assure success for *your* new, specialized implements, make sure they're designed for p.t.o. drive—and equipped with Blood Brothers Jointed Drive Lines.

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FOR FARM IMPLEMENTS, MORE BLOOD BROTHERS UNIVERSAL JOINTS ARE USED THAN ALL OTHER MAKES COMBINED.

### **BLOOD BROTHERS MACHINE DIVISION**

ROCKWELL SPRING AND AXLE COMPANY

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS  
AND DRIVE LINE  
ASSEMBLIES



# AGRICULTURAL ENGINEERING

Established 1920

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**CONTENTS • OCTOBER, 1955 • Vol. 36, No. 10**

---

Mounted Grain Drill Development . . . . .	649
A. G. Buhr	
Lateral Pressures in Horizontal Silos . . . . .	651
M. L. Esmay and D. B. Brooker	
Field Determinations of Soil Moisture . . . . .	654
Sterling A. Taylor	
Lubricants as Engineering Materials . . . . .	660
N. A. Sauter	
Punched Cards Record Runoff and Soil-Loss Data . . . . .	664
W. H. Wischmeier	
Aeration of Stored Grain . . . . .	667
Leo E. Holman	
Evapotranspiration Rates for Various Crops . . . . .	669
Lloyd L. Harrold	
Instrument News . . . . .	673
News Section . . . . .	674
Index to Advertisers . . . . .	704

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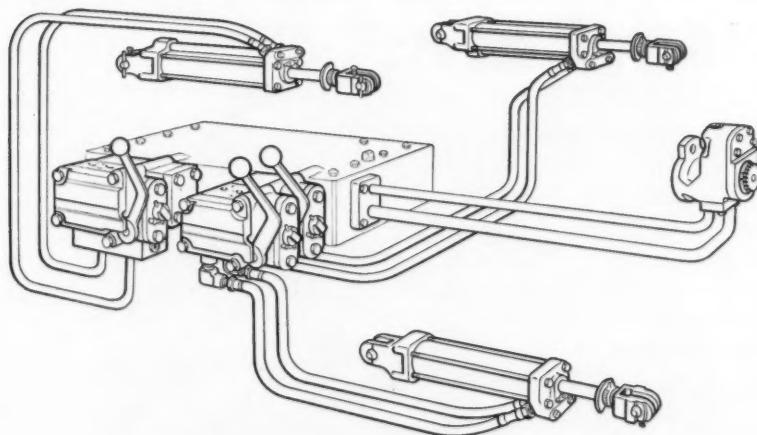
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# How new HYDRA-TOUCH provides IMPLEMENT CONTROL UNLIMITED!

With Hydra-Touch, the owner of any Farmall® or International® 300 or 400 series tractors can hydraulically control a wider range of equipment, more easily and completely, than ever before in farm tractor history! It's easy to see why:

- The tractor can be equipped with one, two, or three Hydra-Touch control valves.
- Either single or double-acting cylinders, or a combination of both can be used, *individually* or at the same time.
- Any degree of control desired by the tractor owner can be obtained for trailing, Fast-Hitch, front-mounted and center-mounted equipment, *individually or together*. Roving cylinders greatly reduce complicated mechanical linkages.

Only Hydra-Touch can easily be tailored to any owner's complete implement control needs!



**Typical three-valve Hydra-Touch system** for International 300 Utility tractors. Here, each of three valves controls a roving cylinder. If desired, two cylinders may be inter-connected for simultaneous control with one lever. Cylinder hoses are equipped with self-sealing couplings.

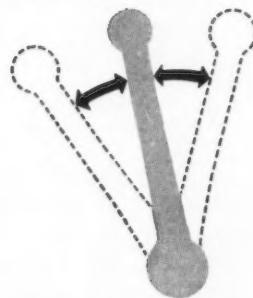
**IH engineering teamwork** produced Hydra-Touch for Farmall 300 and 400, International 300 Utility, and International W 400 tractors. IH research, engineering, and manufacturing men are constantly pooling time and talent to provide equipment of improved performance, making the farmer's work easier while boosting his manhour output.



Simply turn an indicator on the control valve to use single or double-acting cylinders—or to permit implement "float."



One control can activate two or more cylinders, using a dual junction block.



**Automatic hold and return.** Simply flip lever to raise or lower implements. When action is completed, control lever automatically returns to neutral. For safety, check valve prevents Fast-Hitch implements from dropping if controls are moved when engine is stopped.

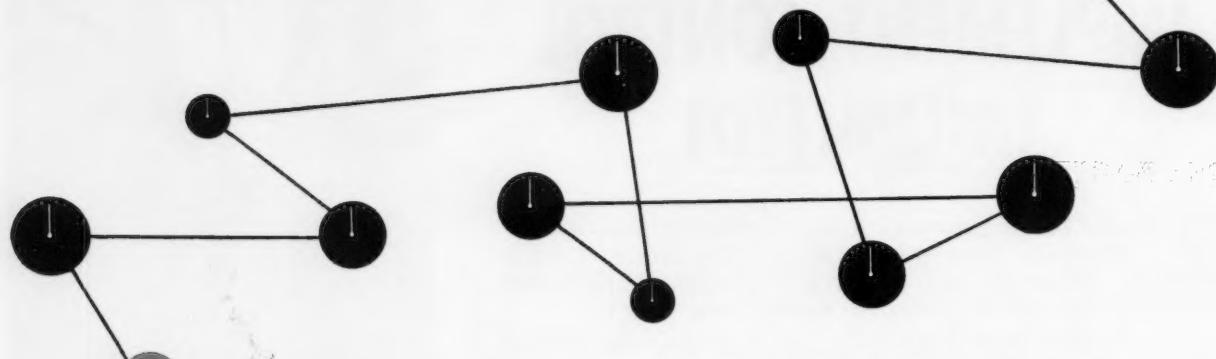


## INTERNATIONAL HARVESTER

International Harvester products pay for themselves in use—McCormick Farm Equipment and Farmall Tractors . . . Motor Trucks . . . Crawler Tractors and Power Units . . . Refrigerators, Freezers and Air Conditioners—General Office, Chicago 1, Illinois.

# THE FUTURE

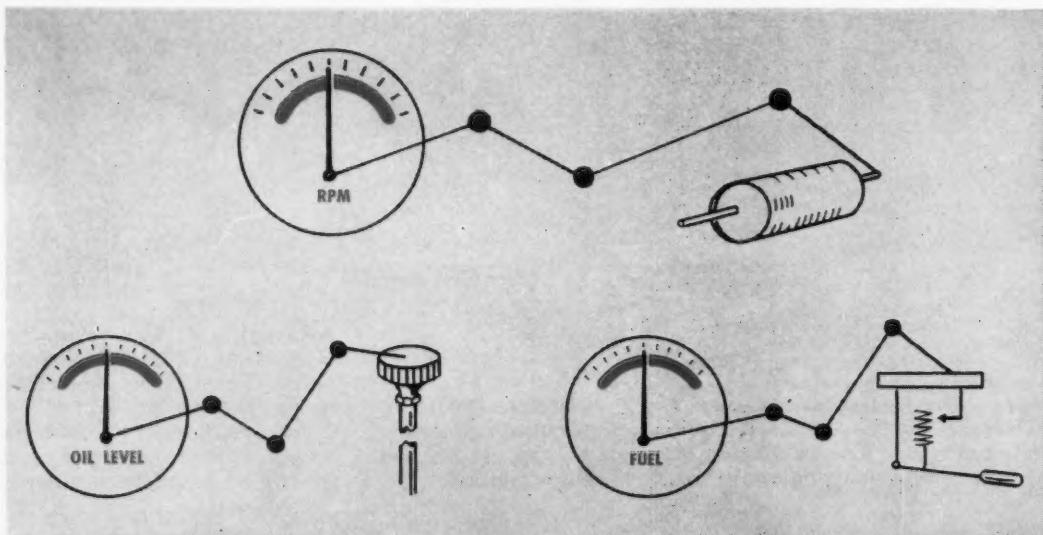
## FOR TRACTOR INSTRUMENTATION



**M**EN IN AMERICA's great agricultural and building industries are looking to tomorrow's tractor for greater power and more efficiency.

New and more powerful fuels and better power plants are bound to come and they call for operating instruments like Rochester Manufacturing is today designing and testing. These include new electrical type Tachometers, fuel and oil gauges, ammeters and pressure gauges. Representing these are the fine, precision made instruments currently manufactured by the Rochester Manufacturing Company.

Better tractors—better tractor usage through more complete instrument control are the plans we share with the industry for today and tomorrow. So put Rochester Manufacturing's Engineering and Production facilities into your plans for the future—with tractor gauges that have kept pace with the industry.



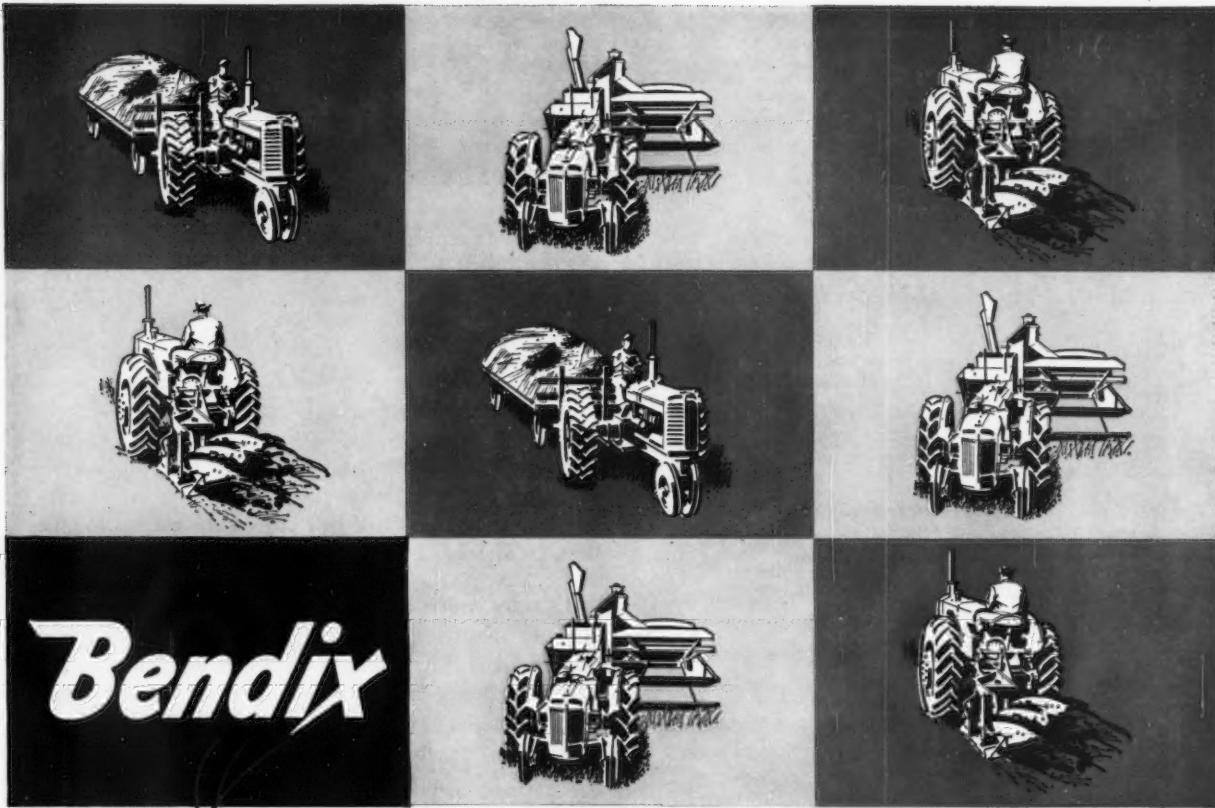
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DIAL THERMOMETERS • GAUGES • AMMETERS

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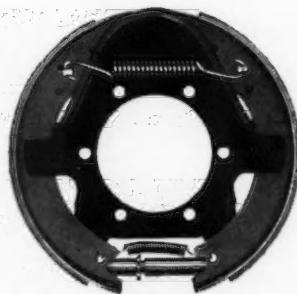


**Bendix**



## Farm Tractor Brakes...

**backed by the greatest name in braking**



The Bendix heavy-duty farm tractor brake has powerful and positive holding action in both forward and reverse. Rugged design assures uniform performance day after day, under the most severe field and road work.

For 25 years Bendix has specialized in building brakes for the automotive industry. In that period of time the Bendix Products Division at South Bend has built more than 90 million brakes for passenger cars, trucks and farm tractors.

These are reasons why tractor manufacturers—as well as passenger car and truck manufacturers—look to Bendix as brake headquarters.

Bendix Brakes for farm tractors are specifically designed for the exacting needs of this class of service, combining rugged, dependable and smooth action with low cost. That's why Bendix Brakes are the logical choice for the modern tractor.

Let Bendix\* farm tractor brake engineers help you solve your brake problems. Write for detailed information.

\*REG. U.S. PAT. OFF.

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DIVISION • SOUTH BEND**

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# Torture tests pre-determine performance of V-Belts for rugged cylinder drives

**Dayton V-Belts are subjected to grueling lab and field runs to obtain advance proof of endurance and economy.**

Implement manufacturers specifying Dayton Agricultural V-Belts for all V-drives know beforehand that every type V-Belt has a tested capacity and quality control for meeting maximum drive needs.

**They know Dayton V-Belts** will give long, economical performance because each one is a graduate of a series of the most tortuous lab tests ever devised by Dayton Agricultural Engineers. They know, too, the strenuous laboratory punishment dealt out to Dayton V-Belts is followed by field runs designed to duplicate and simulate years of operation under the most rigorous conditions possible.

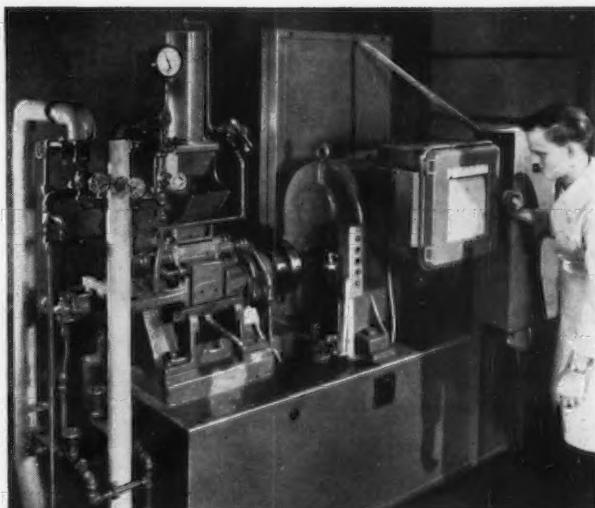
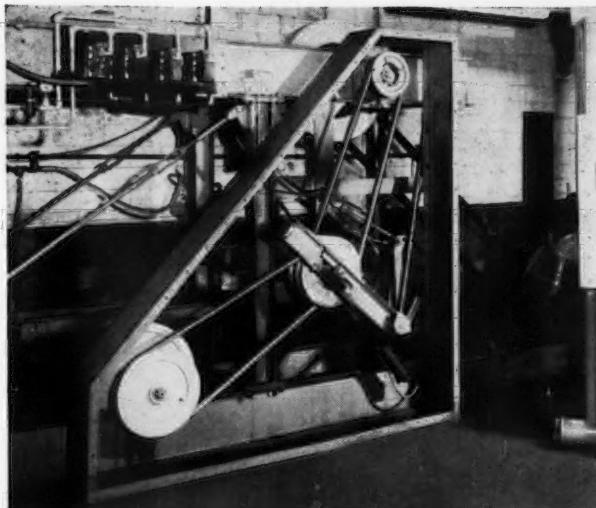
**A good example** are the tests applied to Dayton D-Section V-Belts designed and built for combine cylinder drives—the most critical of all implement operations. No mambypamby trials are these to make the V-Belts look

good but, instead, the roughest treatment conceivable to try them to the breaking point.

**Lab and field results** are then correlated to substantiate each other and prove Dayton Agricultural V-Belts, drive for drive, to be the best V-Belt buy on the market for the assurance of long, economical service.

**That's why more and more** farm equipment manufacturers are specifying Dayton V-Belts as component parts every day. And, why farmers everywhere are glad they do. So for *more power for your money*—consult Dayton V-Belt engineers on how to improve your present and future drives with stronger, longer lasting Dayton V-Belts! Dayton Rubber Co., Agricultural O.E.M. Div., Dept. 408, 1500 S. Western Ave., Chicago, Ill.





### Lab-Tested for Superior Strength and Flexibility

Cylinder drive V-Belts are given full slug load tests on cycling test unit to determine capacity to withstand shock, snap, backlash and heavy pulsation.

Raw materials that go into the production of Dayton Agricultural V-Belts are rigidly laboratory-tested to insure quality control during manufacture.



### Field Tested for Endurance and Stamina

Laboratory tests are followed by actual field tests under all conditions of terrain and weather to provide further proof of Dayton V-Belt quality.

Whether on Variable Speed, Back Side Idler or Cylinder drive, Dayton V-Belts give maximum, continuous operation on the drive for which they have been developed.

**Pull-Type or Self-Propelled, Dayton's outperform all others.** Dayton pre-tested V-Belts are top choice for all V-drives on Pull-Type and Self-Propelled combines alike. Because of their amazing tensile strength, Heavy Section Dayton V-Belts are rapidly building up success stories on the rugged self-propelled cylinder drives similar to the performance records that have become routine on Pull-Type applications.

© D.R. 1955

**GOLDEN JUBILEE**  
**Dayton 50 Rubber**  
YEARS OF PROGRESS

First in Agricultural V-Belts

Agricultural Sales Engineers in Chicago, Moline,  
New York, San Francisco, Atlanta and St. Louis

# Clean take-off in a dust storm



## IPTO LIVES CLEANER, LONGER—C/R SEALED

Clouds of dirt and dust swarm over the Independent Power Take-Off on this Farmall 400 almost every day in the field. But its bearings and gears never bite that dust. They bathe in clean, pure oil for a long lifetime. C/R's Type A Oil Seal is the life-guard. It locks out dirt and dust, seals in SAE #10 oil securely at 200° F. as the IPTO shaft turns up to 534 rpm. This C/R Oil Seal has proved its rugged dependability in thousands of hours in the field, is saving costly downtime on one of the most demanding jobs—where good machines and men must make hay while the sun shines. Whether your sealing problem is simple or equally critical, consider C/R Oil Seals. Get in touch with C/R Engineers or write for your copy of "C/R Perfect Oil Seals."



More automobiles, farm and industrial machines rely  
on C/R Oil Seals than on any similar sealing device

**CHICAGO RAWHIDE MANUFACTURING COMPANY**

1301 Elston Avenue OIL SEAL DIVISION Chicago 22, Illinois

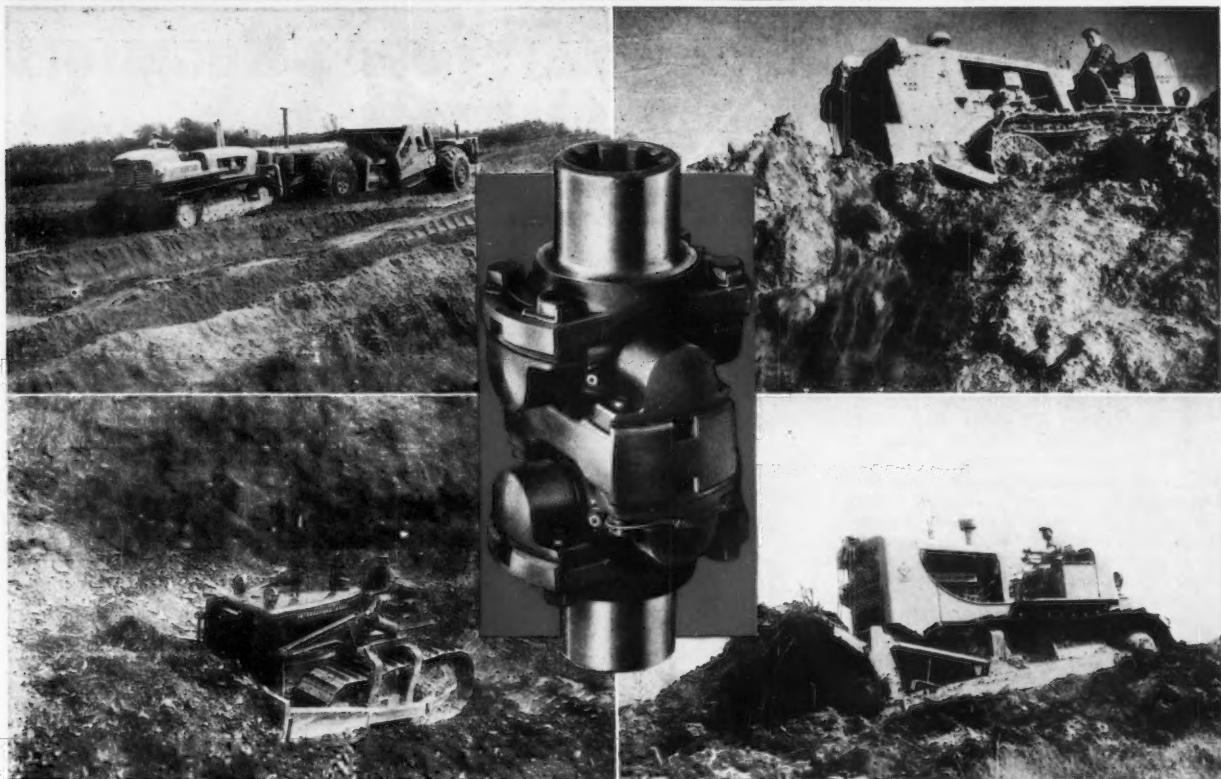
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SIRVENE: (Synthetic rubber) diaphragms, boots, gaskets and similar parts for critical operating conditions • CONPOR: Controlled porosity mechanical leather packings and other sealing products • SIRVIS: Mechanical leather boots, gaskets, packings and related products.

# BIGGEST



All of the world's "biggest" tractors depend on MECHANICS Roller Bearing UNIVERSAL JOINTS to compensate for heavy-duty shocks and strains — severe enough to twist tractor frames. MECHANICS key-drive strength, flexibility and balance are unanimously specified by the largest tractor manufacturers to keep huge capacity machines operating long hours, day-after-day. They

can't afford to permit large tractors and equipment to be kept idle by needless down-time. Let MECHANICS engineers help build reliability into your (200 to 50,000 foot pounds torque capacity) machines.

MECHANICS UNIVERSAL JOINT DIVISION  
Borg-Warner • 2046 Harrison Ave., Rockford, Ill.

## MECHANICS Roller Bearing UNIVERSAL JOINTS

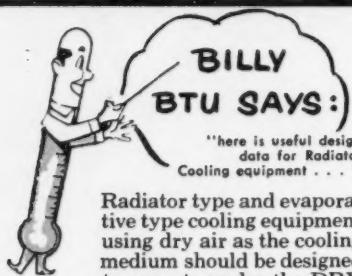
For Cars • Trucks • Tractors • Farm Implements • Road Machinery •  
Aircraft • Tanks • Busses and Industrial Equipment



# Young Heat Transfer News

YOUNG RADIATOR COMPANY, RACINE, WIS.

## Allis-Chalmers SPECIFIES Young Radiators for models CA and WD-45 Tractors



Radiator type and evaporative type cooling equipment using dry air as the cooling medium should be designed to operate under the DRY BULB air temperatures to be expected during the summer in the locality where the equipment is to operate. Equipment using cooling effect due to water evaporation is designed to operate under the WET BULB air temperatures to be expected.

For proper design, it is not satisfactory to use either the maximum air temperature, nor the average air temperature. Use of the maximum air temperature for design would result in the selection of cooling equipment too large to be economical, since it would be fully loaded only under the most extreme temperature conditions. Use of average temperature for design purposes would result in selection of equipment too small to handle the cooling load during a great portion of the operating time. It is necessary, therefore, to use some figure between maximum and average air temperatures.

The Young Radiator Company has prepared and offers to engineers engaged in the design and application of radiator type and evaporative type cooling equipment, data taken from the results of five years of summer records in the United States. This data may be used and considered as applying to an average year.

For a copy of this data, write for Bulletin 654, Young Radiator Company, Racine, Wisconsin.



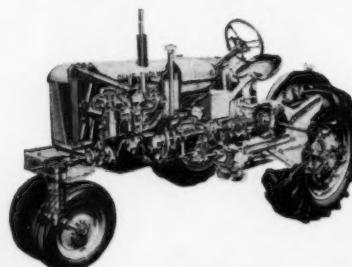
### WRITE FOR FREE DESIGN TEMPERATURE BULLETIN OF THE UNITED STATES

Helpful four-page Bulletin briefly discusses atmospheric cooling equipment design temperatures for the United States. Wet and dry bulb maps are fully illustrated with isothermal lines. Write Young Radiator Company, Dept. 295-K, Racine, Wisconsin.

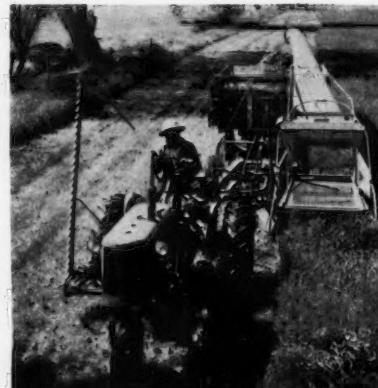
### Drawn Tank Radiators Meet All Tractor Cooling Loads

Allis-Chalmers Manufacturing Company, West Allis, Wisconsin, uses Young Radiator Company drawn tank Radiators on two powerful tractor models.

Built to withstand the constant strain and stress put upon tractors, these



Cross-sectional view of Allis-Chalmers Model WD-45 Tractor with Young Radiator.



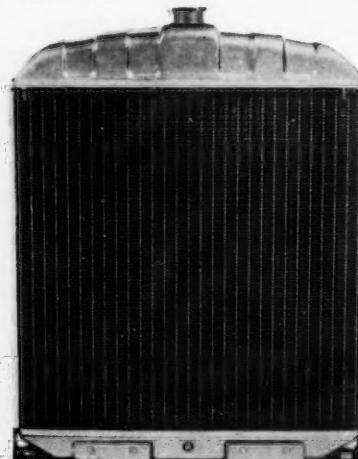
View of Allis-Chalmers CA Tractor and forage harvester making grass silage.

Young units must cope with high internal water impact pressures due to sudden starting and stopping.

To overcome these and other torsional stresses and long term vibrations, full wrap-around type terne plate side members secure tanks, headers and core as one piece. Brass top and bottom tanks are formed as one piece and have die-formed beads for reinforcement. Fabricated brass inlet with maximum flow area provides minimum resistance to coolant circulation.

This Radiator also features Young patented double-grip, two-way headers with lapped joint solder sealed to tanks as a permanent, leak-proof assembly. Fully soldered double-lockseam tubes with corrugated fins makes for strength and maximum air turbulence and greater heat transfer.

For further details, write dept. 295-K, Young Radiator Company, Racine, Wisconsin.



Young Radiator Company drawn tank Radiator used on Allis-Chalmers Model CA Tractor.



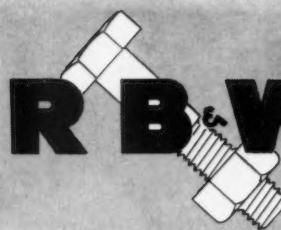
RADIATOR COMPANY

RACINE, WISCONSIN

Creative HEAT TRANSFER ENGINEERS FOR INDUSTRY

Heat Transfer Products for Automotive, Aviation and Industrial Applications. Heating, Cooling, Air Conditioning Products for Home and Industry.

Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois



# RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



## Technical-ities

By John S. Davey

### Coarse Threads Better Than Fine For Many Jobs

The load and stress concentrations on threads are lower in standard coarse thread fasteners than in fine threaded ones. Flank engagement is also greater because coarse threads are deeper. Except in such cases where fine adjustments are needed, coarse threads are, therefore, preferable to fine threads. They have greater resistance to stripping and, consequently, can be more highly torqued to make a stronger assembly.

#### PRODUCTION SAVINGS

Coarse thread fasteners tighten with only two-thirds the revolutions needed for fine threads. So your assembly time is faster, too. Coarse thread bolts enter nuts or mating holes with less tendency to cross thread when not truly positioned. In hard-to-reach areas, this ease of starting can often be your deciding factor. Bear in mind, too, that coarse threads need less "babying" in handling since they're less apt to be damaged.

All in all, coarse threaded standard fasteners prove best for an assembly because of their additional clamping strength—and best for the assembler because of their extra economy and production advantages.

## Spin-Lock screws increase holding power by 20%

EXPERIENCE confirms that Spin-Lock screws hold tight under conditions of vibration or repeated heating and cooling. Their strong teeth have a ratchet action on the bearing surface—the acute angle lets the screw tighten fast and easily, until the teeth actually embed into the seat upon tightening, as shown in the sectional photomacrophotograph below. The almost vertical face of the teeth then resists counter-rotation and loosening. As a result, it takes about 20%

more torque to loosen a Spin-Lock than to tighten it.

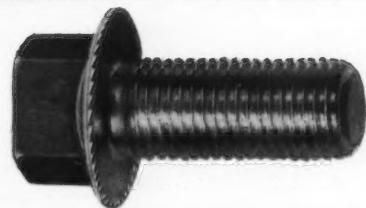
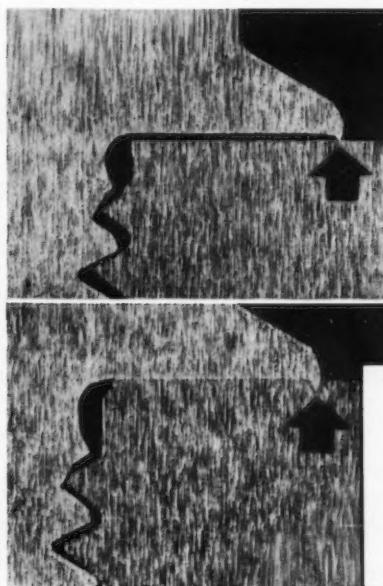
#### LOWER COST ASSEMBLY

Spin-Lock screws avoid need for washers or external locking devices. One-piece construction, they allow faster assembly and can be easily handled and driven in cramped spaces.

#### STRONGER ASSEMBLY

Heat treatment gives the teeth hardness and toughness. Spin-Lock screws can, therefore, be reused when removed with but slight loss in holding power. The extra strength also permits tighter fastening for a stronger assembly without risk of stripping threads.

Screws with hex, pan, truss and flat heads are available. See Sweet's Product Designers file or write Russell, Burdsall & Ward Bolt and Nut Company. Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.



## High strength bolts improved product at a saving

A mechanical vibrating shaker naturally suffers severe abuse itself from vibration. One manufacturer of such machines used costly special fasteners and lock nuts to control tendency of the product to loosen up.

Asked about it, RB&W recommended a standard high strength bolt, heavy nut, and two hardened washers. These

permitted a high tensile clamping force to be developed. Residual tension was ample for the most severe operating conditions and kept the bolts tight. Result: A 25% saving in annual fastener cost, the constant availability of standard items, and less maintenance for the product. You too can draw on RB&W experience for technical help to assure a strong assembly and to cut costs.

# TODAY'S FAST GROWING

"FARM HAND"...

**DIESEL POWER**



In ever-increasing numbers, farmers are turning to Diesel power—for tractors, combines and other types of farm equipment.

A majority of these farm Diesels, with their great labor-saving and money-saving advantages, are equipped with American Bosch fuel injection systems.



The pump that helped make this impressive swing to Diesels possible was the American Bosch PSB. This simplified single-plunger injection pump gave Diesel manufacturers the pump they needed to produce the smaller lower-cost Diesels that are making such a mark in the farm equipment, and other fields.

American Bosch now has produced over 100,000 PSB's in just the few years since it was introduced. During this time, the PSB has achieved a remarkable record for performance and dependability under the most severe operating conditions. American Bosch, Springfield 7, Massachusetts.



3292

**AMERICAN BOSCH**  
Division of  
American Bosch Arma Corporation

Here are some of the farm equipment manufacturers who rely on American Bosch Diesel Fuel Injection Equipment:

Allis-Chalmers  
Case  
Cockshutt  
John Deere  
International Harvester  
Massey-Harris  
Minneapolis-Moline  
Oliver

# NEW! ARMCO ALUMINUM-COATED STEEL for outdoor service

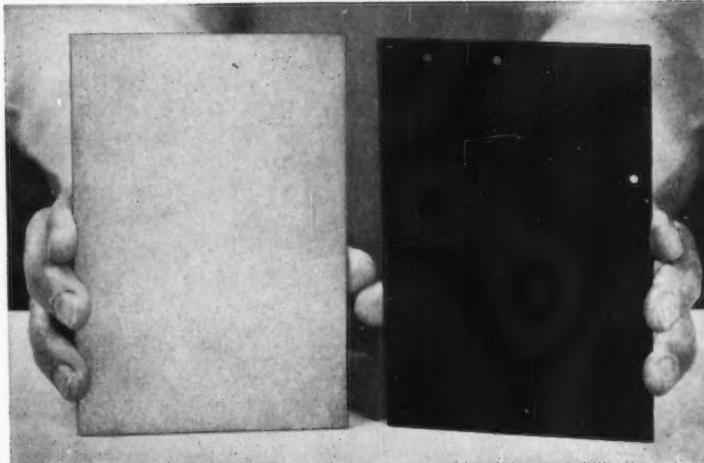
## Combines Corrosion-Resisting Properties of Aluminum with Strength of Steel

A new hot-dip aluminum-coated sheet steel—known as Armco ALUMINIZED STEEL® (Type 2)—is now in production after 15 years of corrosion testing. It combines the surface advantages of aluminum with the strength of steel.

While zinc coatings have done a good job of protecting steel against rust, tests indicate this new aluminum-coated steel is greatly superior. The 15-year tests in an industrial area show the atmospheric corrosion resistance of this aluminum coating is at least 3 times that of a standard coating on galvanized steel sheets.

During the past year and a half of field development work, ALUMINIZED STEEL (Type 2) has been used in prefabricated industrial, commercial and farm buildings, industrial rolling doors, covers for silos and water storage tanks, roof deck, and other applications under general atmospheric conditions.

The new sheet is a companion grade to Armco ALUMINIZED STEEL (Type 1) exclusively produced by Armco since 1939 for high temperature service.



In atmosphere sufficiently corrosive to cause a standard galvanized coating (right) to fail completely in 12 years, Armco ALUMINIZED STEEL (Type 2), left, looked like this after 15 years. Cleaned samples show the aluminum coating is still giving full protection to the base metal.

## QUESTIONS YOU MAY WANT ANSWERED

### DOES IT "WEATHER" LIKE ALUMINUM?

Yes. The surface of samples of Armco ALUMINIZED STEEL (Type 2) and aluminum, exposed to the atmosphere for five years, cannot be told apart.

### WHAT IS ITS STRENGTH?

Because it has a steel base it has the strength and rigidity of steel . . . thus avoiding problems common to weaker materials.

### DOES IT REFLECT HEAT?

Yes, ALUMINIZED STEEL (Type 2) offers the same high reflectivity of radiant heat as aluminum—whether from the sun or from low temperature heat sources.

### DOES IT RESIST FIRE DAMAGE?

Armco ALUMINIZED STEEL has excellent resistance to fire damage. At 800 F, for example, it has more than ten times the strength of aluminum. Steel has a melting point of 2850 F; aluminum melts at about 1200 F.

### WHAT ABOUT FABRICATION?

Armco ALUMINIZED STEEL (Type 2) withstands severe forming without peeling or flaking of the coating. It also can be embossed and spun, but is not recommended for drawing operations.

### HOW DOES IT COMPARE IN COST?

Even when considering equal thicknesses, ALUMINIZED STEEL (Type 2) generally costs less per square foot than aluminum. Additional cost savings are possible because the greater strength of the steel base permits use of lighter gages. For example, a fabricator using .050 aluminum could save 40 to 50 per cent of material costs by utilizing the proper gage of ALUMINIZED STEEL.

While the initial cost is somewhat higher than galvanized steel, it is less than the cost of galvanized plus one field coat of paint. Because of its superior atmospheric corrosion resistance, the new aluminum-coated steel needs no paint protection.

If you would like complete information on sizes, gages and prices of Armco ALUMINIZED STEEL (Type 2), just fill in and mail the coupon.

## ARMCO STEEL CORPORATION

975 Curtis Street, Middletown, Ohio

Sheffield Steel Division • Armco Drainage & Metal Products, Inc. • The Armco International Corporation



ARMCO STEEL CORPORATION, 975 Curtis Street, Middletown, Ohio  
What are sizes, gages and prices of Armco ALUMINIZED STEEL (Type 2)?

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Title \_\_\_\_\_

Company \_\_\_\_\_

Street \_\_\_\_\_

Zone \_\_\_\_\_ State \_\_\_\_\_

# PTO-Baling UP TO 12 TONS AN HOUR with Warner Gear Box

That's a lot of hay, no matter how you bale it! Yet the New Holland "Super 77" power take-off baler does it easily, dependably—hour after hour.

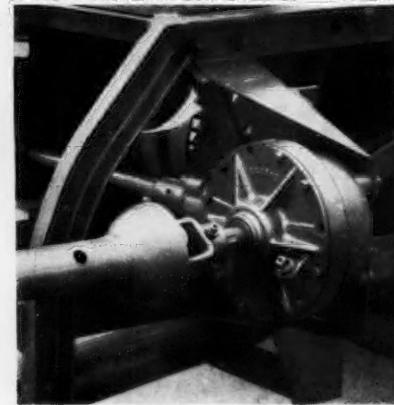
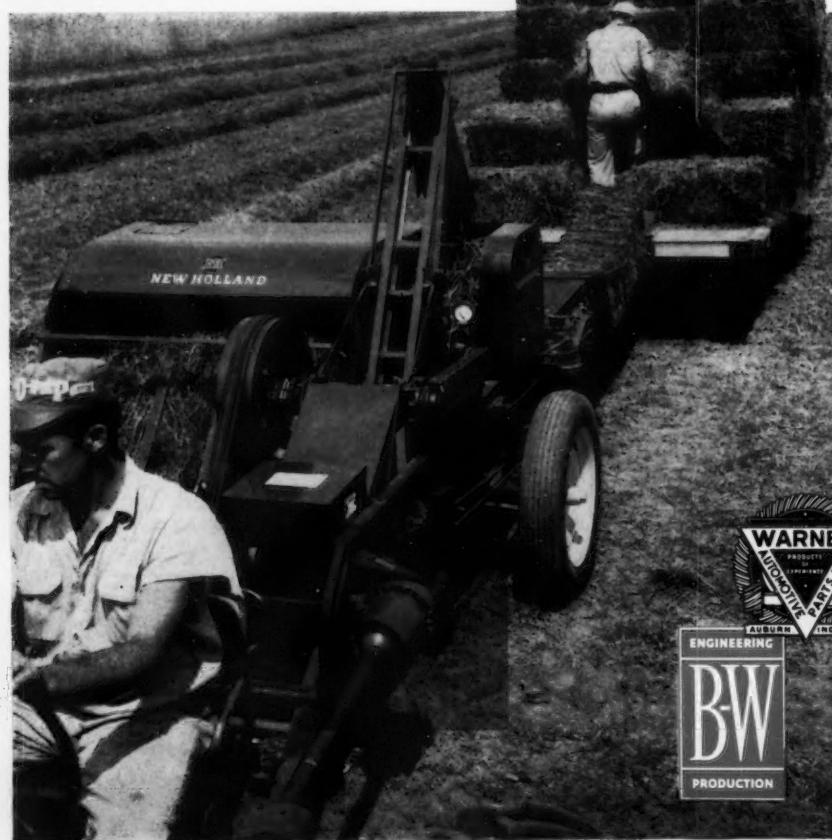
How does New Holland do it? With the help of a specially designed Warner Gear Box with overrunning clutch. This skillfully engineered unit gives the farmer complete control of the entire baling operation, lets him shift tractor gears at will to synchronize ground speed with baling speed for continuous high capacity.

## What's YOUR Gear Box Problem?

If you have a gear box problem, turn it over to Warner Automotive. Warner's pioneering research and experience have licked many a gear box problem for field or brush cutters, hay balers, forage harvesters, spreaders, combines, corn pickers, post hole diggers, hammer mills. And our specialized manufacturing facilities are more than adequate to meet your production schedules.

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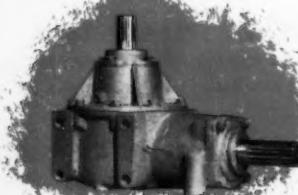


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- **Carburized and hardened alloy gears**
- **Anti-friction bearings throughout, individually selected for load**
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- **Malleable iron housings**



For Combines

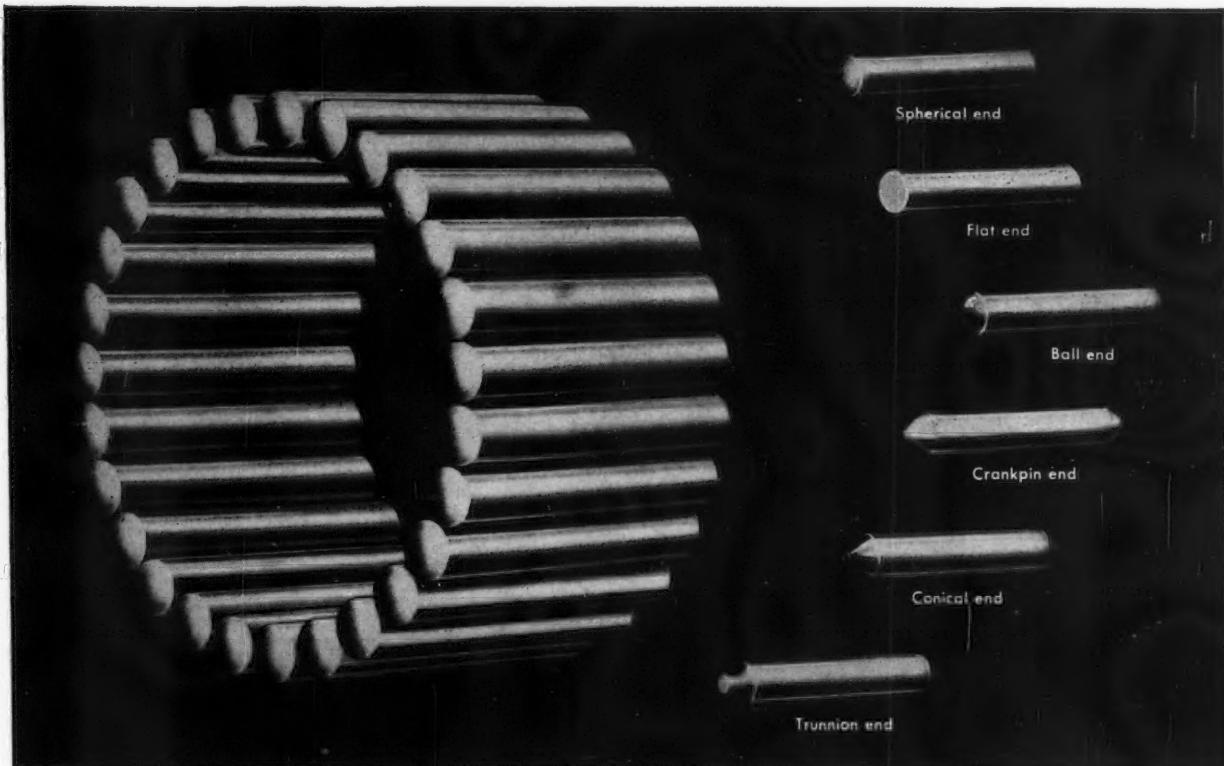


For Brush Cutters

**WARNER**  
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CORPORATION

AUBURN, INDIANA



## **TORRINGTON Needle Rollers**

### *for the ultimate in load capacity at low cost*

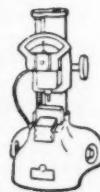
High radial capacity in minimum space stems from full complement of small-diameter rollers. Load zone contains maximum number of contact lines.



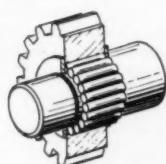
Fine finish contributes to efficient anti-friction performance. Needle Rollers are usually polished to 4-6 rms, but finishes as fine as 1-3 are available on special order.



High carbon chrome steel is carefully hardened, ground and lapped to make each Needle Roller a precision part for long-life performance.



Close tolerances on Needle Rollers are assured by stringent quality controls. Standard OD tolerance is .0002" but rollers can be supplied with OD tolerance of .00005". Tolerance on length dimension depends on end formation.



Mounted without races between hardened shaft and hardened housing (RC-60 recommended), Needle Rollers allow largest possible shaft diameters.

Torrington Needle Rollers provide the lowest cost, highest capacity anti-friction bearings obtainable. They are manufactured in a complete line to meet SAE and AFBMA specifications. Available in the inexpensive spherical end type or in other end shapes, they provide maximum retainerment and fillet clearances or greater lip retainerment. Needle Roller standards for material, heat treat, tolerance and finish are the highest in the industry.

Good operating results with Needle Rollers require careful design of mating parts furnished by the user. The Engineering Department of The Torrington Company, with broad experience in applications of Needle Rollers, will be glad to give you technical advice on your needs.

**THE TORRINGTON COMPANY**  
Torrington, Conn. • South Bend 21, Ind.

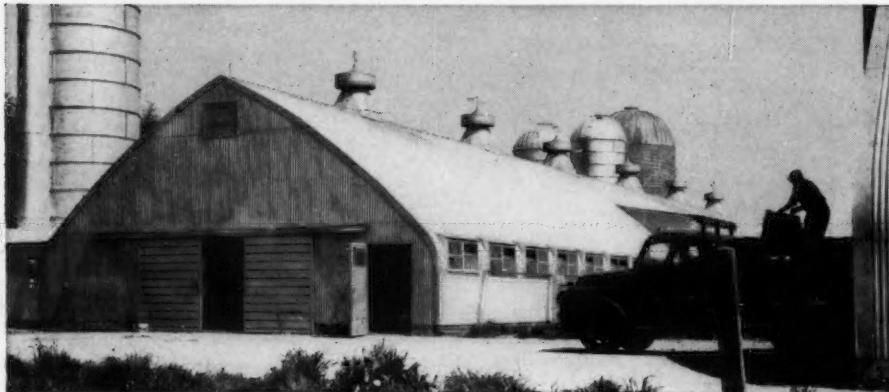
*District offices and distributors in principal cities  
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## **TORRINGTON NEEDLE BEARINGS**

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

# "Steel buildings give our cows freedom of movement, better ventilation, even year-round temperatures, and protection against fire,"

says M. L. Janssen, Kimberton Farms, Chester County, Pa.



**The stanchion barn** consists of two rows of comfort stalls. In the center of the barn is a breezeway in which hand implements and a week's supply of straw are stored. Under the breezeway are outlets for manure which is mechanically scraped from the gutters running the length of the stalls. A ramp allows a manure spreader and tractor to drive under manure outlets for convenient loading.

**Exhaust fans** help maintain even temperatures winter and summer, thus enhancing milk productivity. The 285 head of Guernsey Cows have a herd average, since 1948, of over 430 lbs. of butter fat on 121 head, DHIA figures.

**KIMBERTON FARMS** is a classic example of all-steel farm construction. Owned by Mr. H. A. W. Myrin, it embraces over 960 acres, on part of which is the Guernsey dairy installation shown here.

The dairy installation consists of the following steel structures; a 200'5" x 40' clearspan stanchion barn, a 72' x 24' shop and implement storage building, a 72' x 40' clearspan maternity barn, two 21' x 40' haykeepers and four 12' x 38' silos.

Mr. Janssen, Herdsman for Kimberton Farms, says, "In the milking barn, each cow has 1,250 cu. ft. of air space. Freedom of movement has a definite effect on milk productivity, and that's why we particularly prefer the clearspan type of construction. Also, cows suffer far fewer injuries and are generally healthier.

"Ventilation is much easier in this barn than in the old one," remarks Mr. Janssen. "Stale air pockets are eliminated . . . in the winter the barn is easily sealed against cold weather and we are able to maintain an even temperature year-round—which is certainly good for milk productivity."

Since the old barn was razed by fire, Mr. Janssen says that one of the most important advantages of steel buildings is fire resistance. He has no problem with rodents, either. And the sturdiness of the steel buildings was proved by Hurricane Hazel, he says, since it leveled several barns and many trees in the area but had no effect whatsoever on the Kimberton Farms buildings.

"Our steel milking barn is easy to keep clean, too," concludes Mr. Janssen. "Open construction, efficient gutter manure cleaners and simplicity of working area give us the cleanest possible situation. Milk bacteria count averages only 1,500."

Right now is the time to prepare for the future. Invest in a Factory-Built Steel Farm Building manufactured with long-lasting USS Galvanized Sheets for roofs and walls, and a USS Structural Steel framework.



When buying a Factory-Built Steel Farm Building, ask for USS Galvanized Steel Sheets for roof and sides. These sheets have a zinc coating produced to ASTM Specification A-361. This is your assurance of a high quality building.

UNITED STATES STEEL



#### SEND THIS COUPON FOR FURTHER INFORMATION

Agricultural Extension Section  
United States Steel Corporation  
Room 4949, 525 William Penn Place  
Pittsburgh 30, Pa.

I am interested in steel buildings for the following:

<input type="checkbox"/> machinery storage	<input type="checkbox"/> dairy barns
<input type="checkbox"/> hay storage	<input type="checkbox"/> cattle shelters
<input type="checkbox"/> grain storage	<input type="checkbox"/> poultry houses
<input type="checkbox"/> other .....	

Approximate size or capacity .....

Please have a Steel Building representative call on me with further information.

Send information to:

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Town .....

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United States Steel Corporation produces high-quality USS Galvanized Sheets and Structural Steel which our customers manufacture into durable farm buildings. Your requests for information will be forwarded to the manufacturers of these buildings, and you will hear directly from them.

# BCA



## "package unit" IDLER PULLEY ASSEMBLIES

Speed Assembly...

reduce cost on

**OLIVER Model 50 BALER**



New Oliver Model 50 Twine-Tie Baler. Closeup of main transmission housing and drive (guard removed) shows how BCA package unit Idler Pulley Assemblies are incorporated in design. Sealed ball bearings reduce friction and prolong life...do not require greasing or oiling.

Low first cost...low upkeep cost. Smooth, efficient, trouble-free power. This sums up the new Oliver Model 50 Baler. That's why, in designing this two-way twine-tie model, Oliver Corporation engineers incorporated BCA ball bearing Idler Pulley Assemblies at crucial points in the chain drive. These sealed, pre-lubricated package units give ball bearing dependability at low cost. They're effectively sealed against grit and dust...virtually eliminating field servicing chores.

The Oliver Corporation, as well as other big farm implement manufacturers, finds that BCA package units also speed up assembly time. BCA Idler Pulley Assemblies are adaptable to many other agricultural applications, including combines, forage harvesters, grain elevators, corn and cotton pickers, spreaders. Sheave design can be varied for use with flat belts, V-belts, or chains. If you have a bearing problem, BCA engineering cooperation and design assistance will provide the right solution.



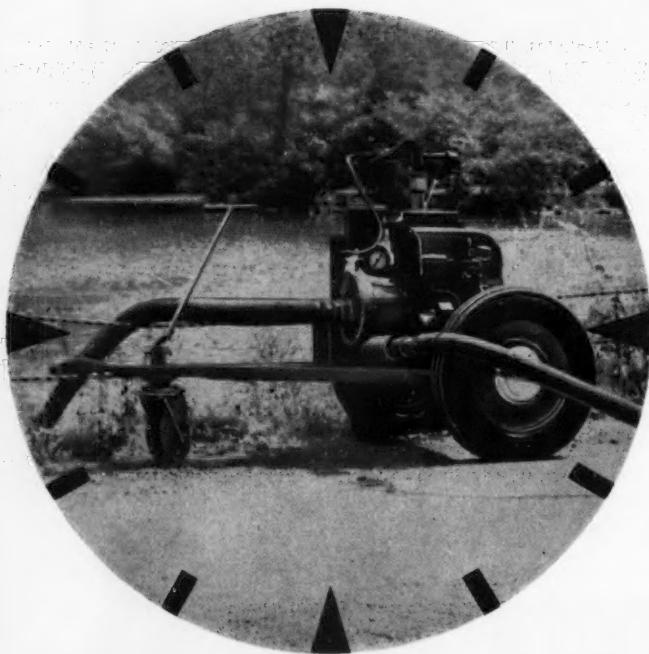
**BEARINGS COMPANY OF AMERICA**  
DIVISION OF FEDERAL-MOGUL CORPORATION  
LANCASTER • PENNSYLVANIA

Pioneers of pre-lubricated package unit ball bearings for agriculture



**NOW...out of 250 million hours of flight experience**

## **A NEW AIR-COOLED INDUSTRIAL ENGINE**



**RUN FOR MORE THAN 1,600 CONTINUOUS HOURS!** In Williamsport, Pa., this C2-90 was test-run in an actual pumping application for more than 1,600 hours continuously, without overhaul or any service except gas and oil. The engine is still in active service as a demonstrator.

### **Designed specifically to solve farm industry problems:**

**New! Reserve Power**—C2-90's full power rating provides a ready reserve for small combines, hay balers, harvesters, row crop sprayers, irrigation pump units, portable sprinklers, etc.

**New! Long Life**—the C2-90 is a ruggedly built engine designed to outlast any other engine on the market.

**New! Cooling Design**—to avoid overheating that comes with dust and chaff conditions, the C2-90 provides improved cooling surfaces, a cooling fan that operates through entire speed range, and rotating shaft screens which toss away chaff by centrifugal force.

**New! All-Weather Performance**—C2-90 advanced air-cooled design performs in extremes of heat and cold.

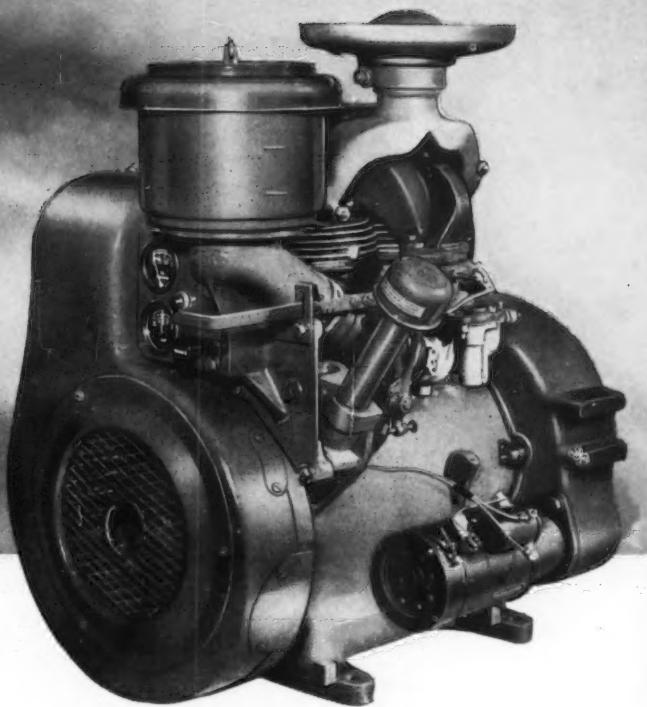
In addition, this short stroke, oversquare engine has the advantage of modern high-speed operating ranges.

*Specifically designed farm equipment accessories are available: gear-driven hydraulic pump; rotating shaft screens; front end power take off; various power take off adaptions, i.e., pulley drives, etc.*

comes

# THE FULL-POWER LYCOMING C2-90

**Rated 30 h.p.! Delivers 30 h.p.!**



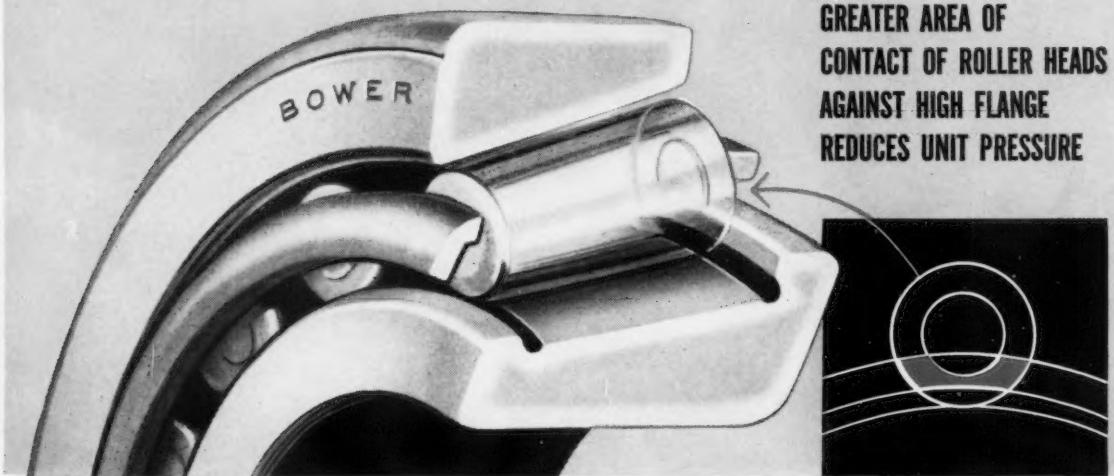
The C2-90 is the result of a quarter century of aircraft experience . . . built to the same high standards that have made Lycoming a top name in engines for aircraft—which demand *absolute* dependability. That is why the C2-90 does just what we say it will do—works at *full power* under the most rugged conditions. So why buy an engine you have to de-rate (up to 50% for continual-duty service)? Here is an engine which continually delivers *full power*!

For more details write to Sales Engineering, Industrial Engines, Lycoming Division of AVCO, Williamsport, Pa.

**SOON TO COME!** New opposed twins, opposed 4's and V-4's for all applications up to 75 h.p.

LOOK TO **Lycoming**  
DIVISION OF  **DEFENSE AND INDUSTRIAL PRODUCTS**  
LYCOMING • AVCO ADVANCED DEVELOPMENT • CROSLEY  
POWER PLANTS • ELECTRONICS • AIR-FRAME COMPONENTS • PRECISION PARTS

# Bower spher-o-honed design increases bearing life



Bower engineers have incorporated many basic refinements into the design of Bower tapered roller bearings which cut maintenance to a bare minimum—increase efficiency. One of the most important of these is the *exclusive* feature illustrated above. Note that the flange at the large end of the cone is *higher*—providing a greater contact area for the roller heads. This greatly reduces wear, improves roller alignment and minimizes resultant "end play". Also note the larger oil groove, providing positive lubrication to the roller heads.

Other important Bower features which increase bearing

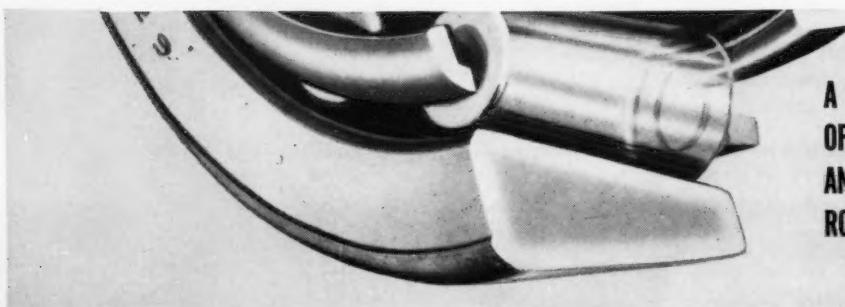
life and dependability are generated spherical roller heads, and smooth, precision-honed races. And Bower bearings are known throughout industry for materials and workmanship of highest quality.

Whether your product is in full production or still in the planning stage, you'll be wise to call in a Bower engineer now. He'll show you a wide range of sizes and types to fit any application.

BOWER ROLLER BEARING DIVISION  
FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICH.

# BOWER

ROLLER BEARINGS

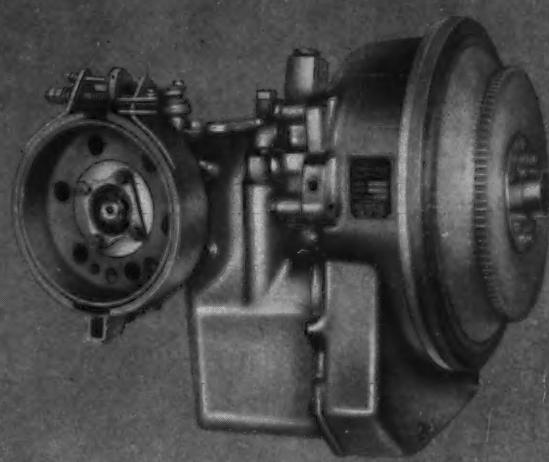


A COMPLETE LINE  
OF TAPERED, STRAIGHT  
AND JOURNAL  
ROLLER BEARINGS



# How to Solve a Problem

CLARK-TORCON CONVERTER UNIT



You see here the solutions to three problems: units for delivering engine-power from flywheel to the point of final drive—for automotive, industrial and construction machines, developed in collaboration with Clark engineers.

The very simplicity of these solutions is in ratio to the seriousness of the problems—to *make sure beforehand* of a machine that would perform efficiently, stand up under hard use and keep maintenance at a minimum.

These Clark units are doing it. Many manufacturers are convinced that it's good business to do business with Clark Equipment.

**Send for attractive pocket-size booklet "Products of Clark".**

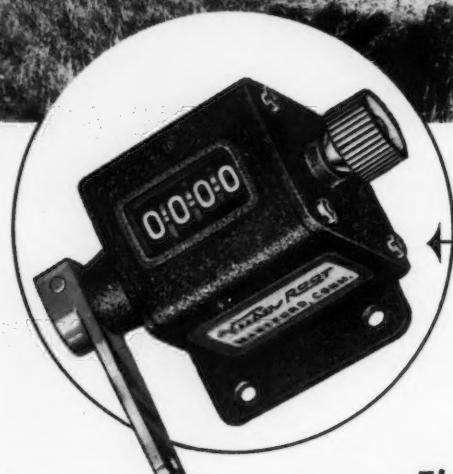
**CLARK EQUIPMENT COMPANY**

JACKSON, MICHIGAN

Other Plants: Buchanan, Battle Creek, Benton Harbor, Michigan



**CLARK**  
**EQUIPMENT**



Better Buys in Balers have

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**VEEDER-ROOT**  
Counters!

*They're easier to reset—easier to read*

On a big baler, this small Veeder-Root Reset Ratchet Counter is a "tremendous trifle". It counts every bale bound.

Easier to reset and easier to read — in addition it's a *direct-reading* counter that adds one for each oscillation of the lever through an angle of 40°. And this is just one of the

many different types of Veeder-Root Agricultural Counters including direct-reading acreage counters for grain drills, spreaders and fertilizers — also counters for all types of tractors and implements — seeders, planters, combines and renovators. Write for bulletin giving full facts and figures.

**VEEDER-ROOT INC.**  
"The Name That Counts"  
HARTFORD 2, CONNECTICUT

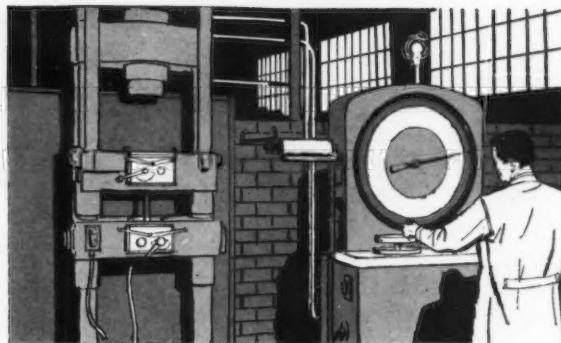


Greenville, S. C. • Chicago 6, Ill. • New York 19, N. Y. • Dundee, Scotland • Montreal 2, Canada

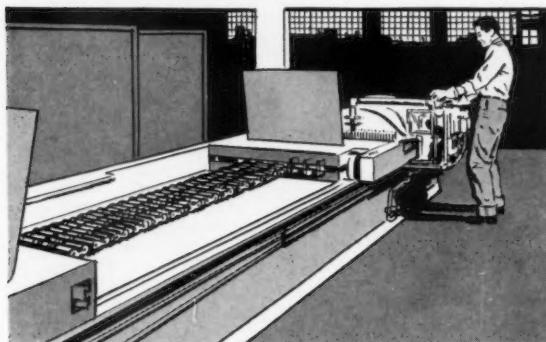
# How LINK-BELT CHAIN *makes* good farm machinery better



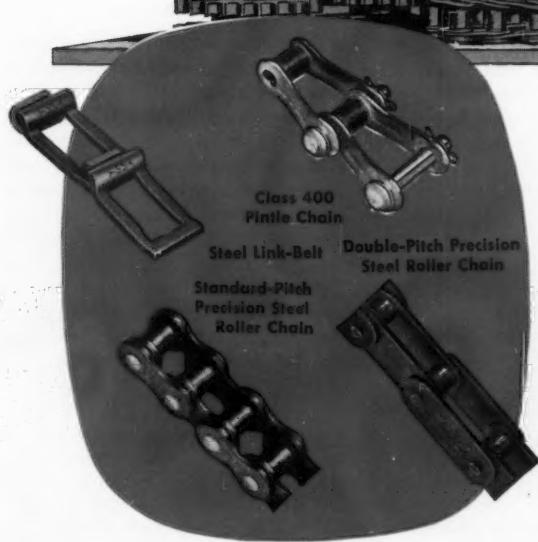
**1. EXPERT ENGINEERING AND FIELD TESTING.** To build both high efficiency and long life into drives and conveyors, Link-Belt maintains an engineering staff of unequalled ability and experience. New developments are thoroughly field-tested.



**2. LABORATORY CONTROL.** Every chain bearing the Link-Belt trade  mark meets rigid uniformity specifications. Our modern laboratory continuously explores new manufacturing refinements to increase chain life.



**3. ACCURATE MANUFACTURE.** In the world's largest chain plant—modern, specialized machines provide the economies of large-scale mass production, yet maintain high accuracy. Continuous inspection safeguards tolerances and finish of every length of chain.



**4. COMPLETENESS ASSURES LOW-COST, PRACTICAL ANSWERS.** With Link-Belt's broad line of chains and sprockets, farm machinery manufacturers are sure to get the *one* chain that's best for each application. Next time you're faced with a drive or conveying problem, look to Link-Belt's complete line. Call your nearest Link-Belt office for full information.

**LINK-BELT**  
THE SYMBOL OF QUALITY

**CHAINS AND SPROCKETS**

**LINK-BELT COMPANY:** Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

# LaBelle

## DISCS

**prescription-made  
by steel specialists...**



Burch Power Lift Flexi-disc on which Crucible LaBelle discs are standard equipment.

It's the *steel* in the disc you buy that counts most in its performance. That's why you can't beat Crucible LaBelle discs—they're made to just the proper toughness and hardness for top discing efficiency by steelmen who have specialized in fine steelmaking for over 50 years.

LaBelle ground edges stay sharp longer—under any soil conditions. And the *prescription-made* steel used in their manufacture gives maximum protection against failure in service.

On new equipment—or for replacements—choose Crucible LaBelle discs. They're available for *all* makes of disc plows and harrows—all soil conditions. And for your free copy of the informative booklet "Soil Improvement with Crucible Agricultural Steels," write: *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pa.*

**CRUCIBLE**

first name in special purpose steels

**Crucible Steel Company of America**

# AGRICULTURAL ENGINEERING

VOL. 36

OCTOBER, 1955

No. 10

## Mounted Grain Drill Development

A. G. Buhr  
Member ASAE

**S**EEING and fertilizing practices are the most important factors under the farmer's control which determine his yield per acre. The rising national average yields indicate that better methods are being put into practice by more and more people. Many important principles in seed and fertilizer placement have been discovered in recent years. Constantly research is teaching more about the mysteries of plant growth, which has pointed the way to more efficient plant production in the past. When new practices are learned, the farm machinery industry develops and manufactures machines to fully utilize these practices.

One of the latest developments by our company in fertilizing and planting equipment is the mounted grain drill—a combination fertilizing, grain and grass-seeding machine.

The drill is rear mounted on our tractors by means of the snap-coupler system and is raised and lowered by the tractor hydraulic lift. Hitches for some other make tractors are available also. It is driven by a sprocket mounted on the tractor rear wheel. It has a reversed hopper arrangement in that the fertilizer, grain and grass-seed compartments are in that order from front to rear. The seed case is an adjustable-rim feed design made to close tolerances. The disk openers place grain and fertilizer in separate bands with the fertilizer band to one side and deeper. Grass seed is placed in bands over the fertilizer or can be broadcast. Depth of seeding is controlled by low-rate torsion springs.

Why mount a grain drill? When we decided to explore this, we had nearly completed the development of a wheeled drill. Using its good features, we designed and built the mounted drill. In field testing this drill, we seeded over 6,000 acres. We were then satisfied that we had a drill with improved performance, easier operation and lower cost. We found that a mounted drill got the job done faster, by measured comparison, than a wheeled drill of the same size. It was equal in acres per day to a wheeled drill 25 percent larger. It permitted faster field travel, quicker turns on the headland and faster travel to and from the field. It saved time in filling the hopper because the mounted drill can be backed up to the grain and

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Urbana, Ill., June, 1955, on a program arranged by the Power and Machinery Division.

The author—A. G. BUHR—is assistant chief engineer, LaCrosse (Wis.) Works, Allis-Chalmers Mfg. Co.

### *Design features of the mounted grain drill and factors leading to its development*

fertilizer truck. It is more maneuverable for working close to fence rows.

It adds traction to the tractor by adding weight to the rear wheels and requires less tractive effort because of the absence of wheels. This results in ability to cross soft spots and steep slopes, and also reduces power loss. Fields are left smoother since there are no visible wheel tracks. This reduces water erosion and promotes more even emergence and ripening of the grain.

The seed case of the drill is a rim feed in which the exposed rim width is varied for the desired seeding rates as in a fluted feed. The body is an aluminum-alloy die casting; the wheel and rim are die-molded sintered iron. These parts are smooth and held to tolerances of 0.010 in. An agitator is built into the seed case. Its travel arc overlaps the feed wheel to eliminate any momentary bridging of the grains. This agitator is mounted between soft compression springs for gentle action on the grain.

The front half of the large hopper is the fertilizer compartment. The feed mechanism is simple, easily cleaned and able to handle foreign material often found in commercial fertilizer. Large helical springs coiled right and left hand serve as agitators and conveyors. Springs were used to prevent jamming or breaking if the fertilizer is lumpy, sticky or has foreign material present. A  $\frac{1}{4}$ -in diam pin, pressed in the shaft over each port, pushes aside or breaks up lumps which would stop the flow. The entire agitator assembly can be removed by pulling five spring pins. This leaves the hopper bottom smooth and clear for cleaning. A slideable

full-length strip with spouts attached align with ports in the hopper bottom. This slideable strip serves to regulate quantity and as a shutoff.

Relative movement between the drill and tractor by means of a chain and spring pulls the slider to an open position when the drill is lowered for work. A tension spring between the hopper and slider closes it when the drill is raised. The size of the opening, or rate of flow, is controlled by an adjustable stop lever which stops the slider at the desired opening. Opening



Fig. 1 The farmers' acceptance of mounted equipment led Allis-Chalmers engineers to explore the possibility of eliminating the wheels from the grain drill. Note the tractor-wheel chain drive in this picture

and closing with tension spring pull allows for minor variations in parts and prevents breakage if the slider should stick. The hopper bottom and slider are removable separately.

Fertilizer is placed deeper than the seed and to the side. To accomplish this desired seed and fertilizer placement, and since costs and simplicity are always major considerations in farm equipment, it was decided to adhere to the single trench with quite conventional single and double disks and provide separation by boot and scraper design. To get the fertilizer deeper in a single trench, it was placed ahead of the seed. The fertilizer is discharged through the front of the twin boots at the point of greatest furrow depth. On the single disk, the conventional toe scraper was extended to the rear and a wiper blade placed diagonally between the fertilizer and seed discharge points. This wiper blade pushes the fertilizer, mixed with some soil, into the lower edge of the trench wall. The seed is deposited in behind the wiper blade on the opposite side of the trench, which has by then started to fill with soil.

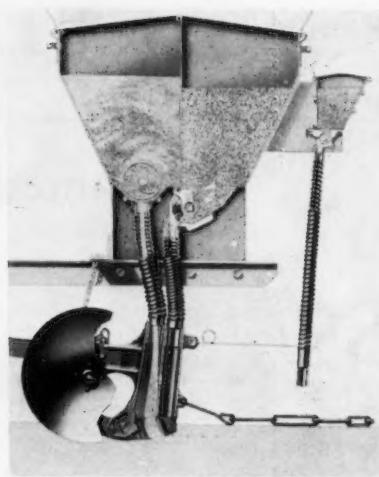
On the double disk, the front of the twin boots leads the fertilizer stream against one blade at the point of maximum penetration. The rear boot discharges the seed against depth where some soil has returned to the trench resulting in a depth as well as width separation of the seed and fertilizer.

Grass and legume seeds in order to be seeded shallower than grain are discharged a distance behind the disk openers where the trenches are again at least partly filled. To minimize discharge problems, the grass seed hopper was mounted behind the grain hopper. Sufficient distance was provided between the grass seed tubes and the disks to prevent the grass seed from being covered too deep. Band seeding is accomplished by keeping the discharge tubes near the ground and positioned laterally over the rows.

The grass seed case is the fluted type. The roll and shut-off are die-molded, sintered iron, the body is die-cast alum-



Fig. 2 (Above) Large helical springs coiled right and left hand serve as fertilizer agitators and conveyors • Fig. 3 (Right) This view shows reversed hopper arrangement with fertilizer, grain and grass-seed compartments in order from front to rear



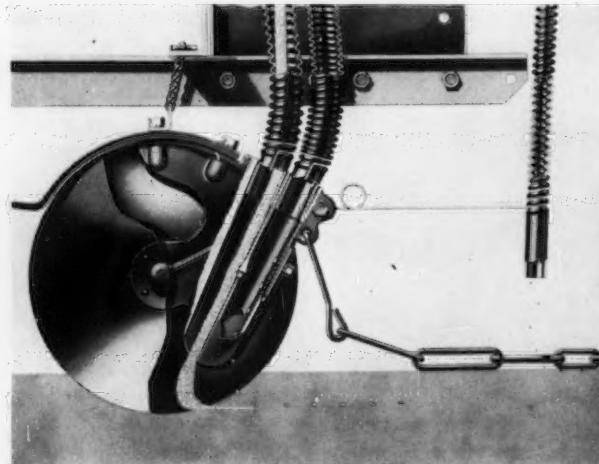
inum and the closure is a steel stamping. Parts have a smooth finish and are held to close tolerances.

The seed and fertilizer discharge tubes are made of rubber. They are fastened at both ends. The flexible length is provided by the convolutions. We found in our test work that the steel spiral tubes we were using were our greatest maintenance problem. With the help of the rubber companies, we developed these tubes, which are quite maintenance-free, have more flexibility and longer life.

A disk opener, since it has little tilt and no point or flat traveling along under the soil, has consequently no soil load or suction to aid penetration. Resistance to penetration and draft-line forces must be overcome by disk-opener weight and spring pressure.

On these disk openers spring pressure is provided by low-rate torsion springs mounted on the disk-gang drawbar. Since resistance to penetration and draft-line forces are quite constant for any one field, equal spring pressure on all gangs results in even depth. To accommodate for unevenness of ground, it is necessary that the gangs have considerable up-and-down freedom with fairly constant spring pressure over the range. We found that a torsion spring would provide much more constant pressure than a compression

(Continued on page 653)



Fertilizer is placed deeper than the seed and to the side • Fig. 4 (Left) Double-disk opener showing front boot discharging fertilizer against one blade and the rear boot discharging seed against the other blade • Fig. 5 (Right) Single-disk opener. Fertilizer is deposited in the lower edge of the trench wall and seed is dropped later on the opposite side of the trench after some dirt has covered the fertilizer band

# Lateral Pressures in Horizontal Silos

M. L. Esmay and D. B. Brooker

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TESTS were conducted at the Missouri Agricultural Experiment Station during the summer of 1953 and 1954 to determine the strength requirements of the walls in horizontal silos. Information on overturning moments developed by the lateral stresses of the silage as packed in the silo was needed. From these data, pilasters, poles, posts and other lateral supports could be designed and an estimate of unit pressures established for the design of the planks and panels between the supporting members.

Fig. 1 shows the test wall panel which consisted of the center portion of one wall of an aboveground horizontal silo. The panel was 20 ft long and 6 ft high, constructed of 20-ft-long bridge planks. The planks were spiked to four upright posts which were hinged at the bottom and supported at the top by lateral braces. Hydraulic cylinders were set under the lower ends of the braces, and gages were used to measure the pressure exerted on the cylinders. The entire test wall panel was free to rotate about the bottom hinges against the lateral supports as stresses were exerted by the silage and packing operations.

Pressure readings were taken on each of the four gages after each load of forage was added during two successive seasonal filling operations. Corresponding silage-depth readings were taken with each gage reading. After each load of silage was packed with the packing tractor, the tractor was removed and pressure readings were taken. Then the packing tractor was run as close to the test wall panel as possible

*A method of measuring lateral pressures exerted on horizontal silo walls by chopped and unchopped silage reveals a pattern of forces that will be helpful in proper wall design*

without rubbing (approximately 1 in away) and the maximum pressure was recorded as the tractor passed each lateral support. Also, after each day of filling, final gage readings were taken. Readings were then taken the following morning before the tractor was run on the silo in order to obtain the amount of pressure relaxation during a period of approximately 12 hr.

A mixture of grasses and legumes taken from various experimental plots on the Soil Conservation Experiment Farm at McCredie, Mo., was put in the silo both years, 1953 and 1954. In 1953 the forages were harvested with a direct-cut experimental English-made machine which did not chop the material into short pieces as do conventional choppers. The forage as cut by this machine came to the silo in what might be termed long-grass or uncut, although the stems were crushed and broken to some extent. This type of forage provided some interesting experiences in handling, storing and feeding unchopped material, but did not develop lateral pressures that might be representative of most silage made in this country. During the second filling operation (in 1954) forages from approximately the same fields were harvested with a conventional field chopper and placed in the silo. This filling not only provided more representative pressure data for grass and legume forages, but provided a comparison with unchopped materials and an opportunity to make some refinements in the testing procedures.

Although the forages put in the silo both years were quite similar with respect to variety of grasses and legumes, there was the difference of length of cut and a difference in moisture content. The moisture content of the unchopped forage as placed in the silo in 1953 averaged about 70 percent. Adequate packing was not obtained with this material. The second year it was decided to add water to the forage at the silo in order to assure good packing and maximum pressures. Moisture samples were taken from each load and the moisture percentages calculated at a later date. The original moisture content of the forage as harvested and brought to the silo in 1954 was 72.1 percent and enough water was added at the silo to bring the total moisture content to 77.5 percent on a wet basis. Both the difference in moisture content and the length of cut, between the two years, undoubtedly contributed to the differences in pressures.

The same packing tractor was used

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Fig. 1 The test wall panel with four pressure gages used on experimental silo for measuring lateral stresses

both years and the same pressure-measuring equipment. The rate of filling during the 1954 season was somewhat faster than for the previous season. The forage packed down considerably better the second year due to the shorter cut of the material and the higher moisture content.

### Findings and Analysis

**Overturning Moment.** The overturning moment caused by silage pressures (tractor not on silo) was first determined. The gage-pressure readings for this condition were converted from pounds per square inch to total thrust on each lateral support. The total thrusts on each lateral support were then reduced to thrust per linear foot of silo wall, assuming each support was affected by the area of wall extending half way to the adjacent support on each side. The resulting thrusts per foot of silo wall were then converted to moments by multiplying by the length of lever arm between the bottom hinge of each support and the perpendicular distance to the lateral supports.

In order to evolve one moment curve representative of all data, average moments for the four gages were tabulated for each depth of silage during the filling operation. The

average moment values per foot of silo wall plotted against silage depth formed a straight line on log-log paper. In order to obtain a curve of best fit for the data, a regression equation was calculated from the logarithms of the moments as the dependent variable and of the logarithms of the silage depths as the independent variable.

Fig. 2 illustrates graphically the curves of best fit for the overturning moment data for field chopped grass and legume silage as tested in 1954 and the unchopped material in 1953. The moment equation for the field chopped material is  $Y = 61.019 X^{1.774}$  and for the unchopped material it is  $Y = 51.261 X^{1.823}$  where  $Y$  is moment in foot-pounds and  $X$  is silage depth in feet. The shapes of the two curves are quite similar. The overturning moments for the unchopped material, however, were about 10 percent less than for the chopped material. The somewhat lower moisture content of the unchopped forage and the springy nature of the long fibers apparently accounted for this. If a moment curve for water was plotted on the same graph it would be somewhat lower than that for the forages up to a depth of approximately 4 ft. Above the 4-ft point the water moment curve would continue on upward much more rapidly than that for forage as packed in a horizontal silo.

**Pressure Relaxation.** By taking final pressure readings at the end of each day during the silo-filling operations and subsequent readings the following mornings prior to the time the packing tractor was put on the silo, estimates of the first 12 hr of pressure relaxation were obtained. Fig. 3 illustrates graphically the amount of this relaxation. A comparable amount of relaxation was observed for the unchopped forage. The amount of relaxation for the chopped forage amounted to from 15 percent of the original overturning moment at the 6-ft depth and increased at lesser depths to 50 percent of the original moment at the 1-ft depth. Although a silo will have to be constructed to resist all of the stresses the first 12 hr as well as later, the relaxation is of interest in a study of pressure characteristics of packed forage.

**Superimposed Tractor Load.** The data taken while the tractor was packing the silage were treated similarly to the silage data, except that the overturning moment of the section of panel supported by each post was computed rather than the overturning moment of 1-ft width of panel. Regression equations for curves of best fit were tabulated in order that the additional overturning moment due to the weight of the tractor might be determined. Fig. 4 illustrates graphically the results for one representative gage. The total overturning moment caused by the silage only, as shown by the solid curve

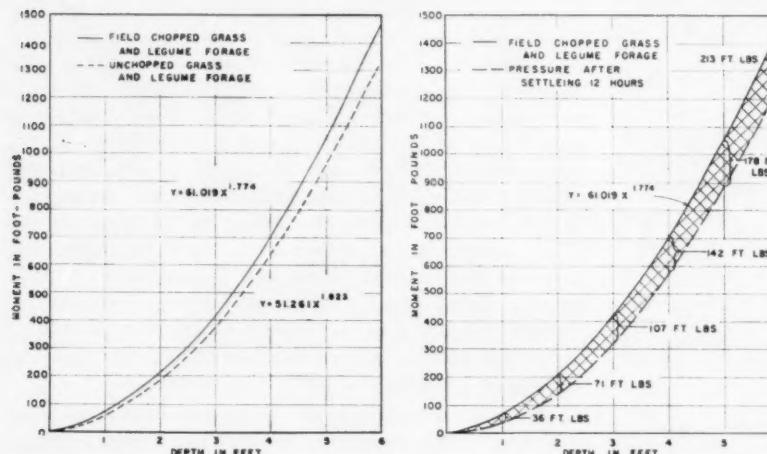


Fig. 2 (Left) Horizontal silage stresses of chopped and unchopped silage per foot of silo wall length • Fig. 3 (Right) Decrease in silage stresses per foot of silo wall length after 12-hr period

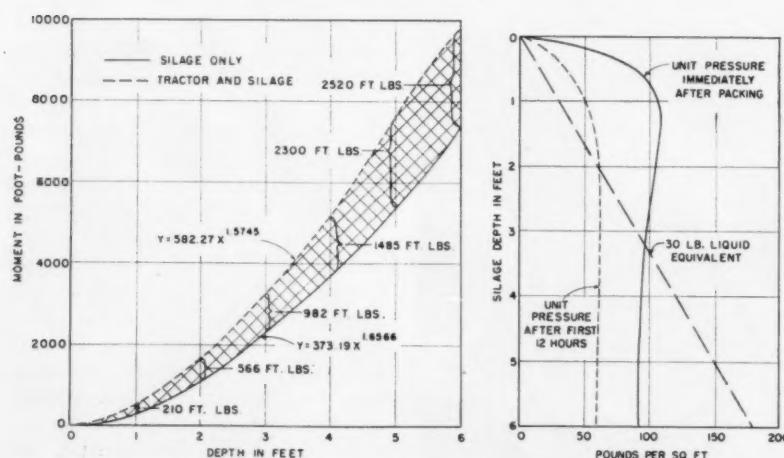


Fig. 4 (Left) Lateral stresses caused by packing tractor as measured by one test gage • Fig. 5 (Right) Approximate lateral unit pressure of chopped grass and legume forage

in Fig. 4, was found to be  $Y=373.19X^{1.6566}$ . A similar moment curve for the silage plus the tractor was found to be  $Y=582.27X^{1.5745}$ . The  $Y$  in these formulas is the total overturning moment caused by lateral stresses on that part of the panel supported by the lateral brace and gage. The additional overturning moment caused by the tractor is illustrated numerically on the graph for each foot of silage depth. The additional overturning moment caused by the tractor increases from 210 ft-lb at 1 ft of silage up to 2520 ft-lb for the 6-ft depth.

Inasmuch as this additional tractor loading is of a type that is applied and then immediately relieved, the lateral stress can be assumed to be a concentrated lateral force at the top surface of the silage. Using this assumption, the lateral forces can be determined at each foot of depth by dividing the overturning moments at each depth by the respective depth in feet. For example, 2520 ft-lb for the 6-ft depth divided by 6 indicates the equivalent of a 418 ft-lb lateral force at the top surface of the silage. For various gages and at various depths this lateral force varied from 100 to 600 lb, with a majority of such loads falling within a range of 300 to 400 lb. A design figure of 400 lb is suggested. The weight of the rear wheels of the tractor used in this study was 4180 lb, or about one ton per wheel.

The lateral force of 400 lb at the surface of the silage is significant from a design standpoint. It will be noted by studying the graphical data that the overturning moment caused by the packing tractor is equivalent to that caused by the silage stresses on a vertical section of the silo wall 2 ft wide. In considering the design of the panels between the lateral supports, such as pilasters or posts, the bending moment caused by the concentrated tractor load may be nearly as large as that caused by the silage. For example, a panel 10 ft long would have a bending moment of 1000 ft-lb per ft of width caused by the tractor and 1250 ft-lb from the silage. Due to the magnitude of this tractor force, it would seem desirable to design for it, even though a temporary load, as the factor of safety used in ordinary design will permit the wall to take the occasional tire rubs and other accidental additional stresses.

**Lateral Unit Pressure.** Unit-pressure data are required for the design of the wall materials which extend between the pilasters or other upright supports. Although unit pressures were not measured directly with the testing equipment used for this study, some indication of the magnitude and shape of the unit-pressure curves were obtained from the moment curves.

When liquid-equivalent pressures were assumed and the data from the moment curve used to compute the liquid-equivalent weight of a fluid that would give the same overturning moment as was measured, the results were irrational. For example, when the silage was 1 ft deep the liquid equivalent weight was 360 lb per cu ft, and when the silage was 6 ft deep the equivalent weight was about 40 lb per cu ft. The pressure curve resulting from the use of these liquid-equivalent weights was one which, if used, for computing to moments, produced values considerably larger than the measured-moment values.

It is quite logical that a fibrous material such as chopped silage would have a much different pressure characteristic than a liquid. It is possible where the material is packed from the top with a tractor, that the shape of the pressure

curve is somewhat the opposite of that for liquids, being maximum at the top and minimum at the bottom. Following this line of reasoning it might also be assumed that these higher pressures near the top are the first to be relaxed, and that after a certain elapsed time there would be uniform pressure from top to bottom. This would give a rectangular-shaped area under the unit-pressure curve.

An assumption of uniform pressure seems rational and nearest to actual conditions based on information at hand. Fig. 5 illustrates graphically the unit-pressure curves for the pressures immediately after packing and 12 hr later. These curves were derived by calculating the unit pressure at each foot of depth of silage. These calculations were based on the moment values as measured and on an assumed uniform pressure distribution. From the curve plotted in Fig. 5 it appears that a unit lateral pressure of approximately 100 lb per sq ft would be a logical figure to use for design purposes.

#### Summary of Findings

1 When grass and legume silage is tractor packed in a horizontal silo the lateral forces on the sidewall cause an overturning moment expressed by an equation of the type  $Y=AX^b$  where  $Y$  is the overturning moment in foot-pounds (measured immediately after packing) per foot of length of silo wall, and  $X$  is the depth of the silage in feet. The constants  $A$  and  $b$  as determined from these tests are 61.019 and 1.774 respectively for field chopped and 51.261 and 1.823 for unchopped forages where  $Y$  and  $X$  are the same as above.

2 Under the conditions of these tests the overturning moments caused by the unchopped silage, as measured immediately after packing, were approximately 10 percent less than those caused by chopped silage.

3 An appreciable portion (15 percent when the silage is 6 ft deep and 50 percent when the depth is 1 ft) of the initial overturning moment caused by packing grass and legume silage in a horizontal silo is relieved during the first 12 hrs following packing.

4 The lateral point load at the surface of the silage caused by the tractor as it packs near the silo wall varies from 100 to 600 lb with a majority of such loads as determined by these tests falling within a range of from 300 to 400 lb. It appears that a point load of at least 400 lb at the silage surface should be used for design purposes.

5 The shape of the lateral unit-pressure diagram of the silage on the silo wall appears to vary with depth as the silo is filled, and although the shape of the diagram was not exactly determined in these tests it is demonstrated that the lateral unit pressure of silage as packed in a horizontal silo cannot be calculated by using liquid-equivalent pressures as previously has been done in upright silo design.

6 For design purposes a lateral pressure of the silage against the wall of 100 lb per sq ft for all depths is recommended.

#### Mounted Grain Drill Development

(Continued from page 650)

spring which for space consideration must be short. The resulting pressure change on the disk blades is 10 lb over the range of movement. The screw crank provides for the selection of the desired pressure and depth.

Field tests showed that seeding was accomplished at a fairly even depth in rough fields and over deadfurrows and backfurrows.

# Field Determinations of Soil Moisture

Sterling A. Taylor

**T**HREE is a growing realization of the value of irrigation in producing crops in both humid and arid-region agriculture. With this realization has come an increased use of water for irrigation in all regions. At the same time, an increased demand has arisen for water in urban areas for domestic consumption and industrial uses. This increased demand for good quality water is resulting in greater and greater competition for the available supplies. In many areas, water is the one factor that is preventing increased agricultural production. In these areas, the wise use of the available water is of concern to everyone.

One of the most important and difficult problems that faces farmers, engineers and scientists in these areas is to determine when and how much water to apply to soils for best crop production. Too heavy or frequent irrigations may decrease soil aeration, promote undesirable chemical and biological reactions in the soil, and be wasteful of water. Too light or infrequent irrigations may permit droughty conditions with resultant limitation in yield and quality of crops.

Where water is available on demand, visual characteristics of plant and soil are often used to indicate the time of irrigation. Sometimes soil samples are taken in the field; they are then weighed, dried in an oven and reweighed; the loss in weight represents the amount of water that was present in the soil. This is expressed as a percentage of the dry weight of soil ( $P_w$ ), or if the original volume is known, it might be expressed as a percentage of the bulk volume of the soil as it occurred in the field ( $P_v$ ); the water ratio ( $R$ ), which is the fraction of the bulk volume that is filled with water might also be used. This gravimetric procedure gives the quantity of water in the soil, but does not indicate the availability of this water to plants. In order to use this information to indicate either when to irrigate or how much water to apply, information is needed for each soil concerning the limits of the available water in the soil.

The tenacity with which water is held in the soil can be measured in the field. This value indicates the relative availability of water to plants. It can then be used to indicate when to irrigate, but the moisture-tension:moisture-content relationship is needed to tell how much water should be applied to the soil at this time.

Tensiometers provide a direct measure of the tenacity with which water is held by soils. Electrical resistance units of various types can be used to measure the soil moisture tension indirectly since the resistance between electrodes imbedded in the units depends on the moisture content of the matrix material, which in turn depends on the soil moisture-tension (along with other factors). Since these latter methods are greatly dependent upon the force with which water is held in the soil, they are adaptable to wide variations in soils without changes in calibration. This is of considerable value in field use since calibration curves for each

*A comparison of several methods of measuring moisture which shows that none of the presently available field methods are completely satisfactory*

soil are not needed in order to determine the proper time for irrigation.

Several methods of measuring moisture have been critically evaluated over years of research. Recently a new kind of resistance device, the concentric electrode moisture plug, has been tested.

## Tensiometer

The porous-cup tensiometers used in these studies were patterned after the instruments described by Richards (12)\*. There are several more recent developments that are sometimes incorporated into the design, including an instrument wherein all tubing is of plastic, which reduces somewhat the thermal conduction of the instrument.

Tensiometers of similar design have been successfully repaired, installed and serviced by college students. Sometimes cups have been made and complete instruments assembled and used by these same students. It is not now necessary to make porous cups, however, unless special sizes are needed. Many good-quality ceramic filter cones have satisfactory water-transmission properties and may be used when specially designed cups are not available. Good porous cups must exclude air from passing through the walls and into the cup at pressures of at least 20 lb per sq in. A cup can be tested by immersing it in water, applying pressure of 20 lb per sq in (or greater if desired), then observing for two or three minutes to find out if air bubbles are formed on the surface of the cup; if so, the "bubbling pressure" is too low and the cup is probably not satisfactory and should not be used. If no air bubbles appear on the surface of the cup, then the "bubbling pressure" is satisfactory and the cup can be used in making tensiometers.

The greatest source of error in tensiometer use that we have found arises from air getting into the system and causing erroneous readings of the instrument. Air might enter through the cup, or through joints that are not vacuum tight. Some kinds of plastic and rubber tubing are somewhat permeable to the diffusion of some or all of the gaseous components of the atmosphere; if these materials are used in tensiometer construction, air entry is inevitable. After long periods of use, air will gradually enter even the best constructed tensiometers by solution in the soil water which enters the instrument through the cup when the tension changes rapidly from high to low values. Where fluctuations in tension are not too rapid, however, one or two months may elapse before air bubbles will appear in the instrument. Whenever air bubbles are present in the system, the error in reading is greatly increased; consequently, the instrument should be serviced and air removed as soon as it appears.

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The author — STERLING A. TAYLOR — is professor of agronomy, Utah State Agricultural College, Logan.

\*Numbers in parentheses refer to the appended bibliography.

In a randomized field test it was found that extensive variation was occurring between tensiometer readings. After examination of the cause of this variation, it was found that two factors contributed most to the variance, as follows:

1 There were actual differences in moisture content and consequently moisture tension from place to place in the plots that were treated alike. The coefficient of variation in moisture content for a single observation was between 13 and 29 percent for several tests. This would correspond to a higher variance in tension because of the non-linear nature of the moisture-content:moisture-tension relationship. This could be reduced somewhat by placing instruments in the same relative location with respect to furrows and water source in each plot.

2 Errors resulted from reading the instruments in the field at different times of day. Haise and Kelley (7) found that large diurnal fluctuations occurred in response to the heating and cooling of the metal portions of the instrument and the thermal conduction into the cup by the metal. This set up vapor-pressure gradients and the distillation of water from cup to cold soil, or vice versa, inducing large differences of readings from true values. This could be partially corrected by using tensiometers with no metal parts in contact with the porous cup, but it was best done by taking readings either before sunup or within an hour after sunrise in the mornings.

When these two factors are controlled or eliminated, tensiometers will accurately measure moisture tension in static or slowly moving systems with precision equal to or greater than 1 mm of mercury on a mercury manometer. In rapidly changing systems, water moving in and out of the cup depends on the water transmission properties of the cup. Since there is some transfer of water across the cup, the instrument itself modifies the moisture tension of the soil in immediate contact with the cup; this sets up gradients that cause flow of water through the soil until the entire system is in equilibrium. Miller (9) has proposed and used a modification of the tension indicating part of the tensiometer, which reduces this variation. In rapidly changing systems, the type of modification that he proposes should be of value in increasing precision.

#### Electrical Resistance Units

Resistance blocks made of various kinds of plaster, nylon, fiberglass, and plaster blocks with nylon and fiberglass around the electrodes have been tested for measuring soil moisture. These units are similar in principle but different in detail. In all cases, electrodes are surrounded by a matrix material which is in contact with the soil. Water is transferred between soil and the matrix material. The resistance between the electrodes depends on the amount of water in the surrounding matrix, which in turn depends on: (a) the relative attraction of the soil and matrix material for moisture, (b) the amount of moisture present, (c) the rate that water transfer can be made from one material to the other, and (d) the electrical conductivity of the moisture or solution that is within the electrical influence of the electrodes.

All devices are sensitive to salts, but the fiber units are somewhat more sensitive than plaster units. This has been attributed to the presence of a saturated solution of calcium sulfate in the plaster block so that salt concentration less than this has only slight effect on the resistance of the units.

The sensitivity of change in resistance readings over a small change in moisture tension depends upon the relative attraction for soil and matrix material for water at the various moisture contents. Even if a material could be found that had exactly the same attraction for water as the soil over any given range in moisture contents, there would still not be a 1:1 change in resistance of the units because moisture content and resistance are not linearly related over all values of moisture. All soils have a different moisture retention relationship; hence, it will not be possible to find a matrix material which will give a single moisture content-resistance relationship for all soils. Certain materials can be found to give greater sensitivity over part of the range than other materials, but when this happens, sensitivity over another portion is frequently lost.

All units must be calibrated to read either moisture tension or moisture content. The variability between units made of some kinds of materials is greater than others; consequently, a calibration curve that is used for more than one unit will be in error, the magnitude of which depends on the uniformity of the units.

All units are temperature sensitive. The magnitude of the temperature variation is greater in some units than others, but in all units, it is small relative to many other sources of variation.

Most units show changes in calibration with use. Some show large changes where others have only small changes. The change is believed to be caused by fluctuations in either the pore-size distribution of the material or in the nature of the surface that contacts soil moisture which might be caused by a precipitated coating from the solution.

In some types of units, lines of electrical force extend outside the unit and into the soil. Where this occurs, the contact between the soil and the unit, as well as the nature of the soil itself, affects the measured resistance.

Resistance units have been calibrated to read soil moisture tension by imbedding them in soil placed on a porous plate (13) or pressure membrane (11). In the experiments described below the apparatus was slightly modified to permit electrical contact through insulated fittings in the cell or cooker wall. One-hole, double O rubber stoppers were placed in holes bored in the wall of the cell. A machine screw of appropriate size to fit snugly in the hole through the rubber stopper was inserted. Washers and nuts were used at each end of the rubber stopper and were tightened until the stopper bulged, making a completely air tight seal. Contacts through the cooker walls were made similarly except that several leads could be brought through the same stopper, which it was not necessary to bulge in this case; the connection was made airtight with a good grade of weather-strip adhesive. In early work, one lead of each block was brought through each insulated opening, the other was grounded to the cell or cooker wall. Later it was found that the common lead had the effect of reducing the magnitude of variation of the individual blocks; therefore, this practice was discontinued and all leads were brought through insulated fittings. All data reported were taken with the latter arrangement.

Units have also been calibrated to read moisture content by placing several units in soil containing different amounts of moisture covering the desired range of calibration and placing both soil and units in friction-top paint cans. The

leads were brought through a hole in the top, which was then sealed with cotton and wax. Readings were taken at intervals until no further change in resistance was noted; the cans were then opened and the soil moisture content determined. The resistance at equilibrium was then plotted against moisture content to give the calibration curve. Where a single calibration curve was to be used for a large number of similar units from which only a sample was being calibrated, this method had the advantage of including several units in each can and different units in other cans. This tended to smooth out variation and give a mean curve nearer that for the entire population of units. If each unit is to have a separate calibration curve, this method is not satisfactory. Since temperature fluctuations cause significant changes in the moisture content of the soil inside the cans by distillation and condensation on the can walls, calibrations should always be done under condition of constant temperature.

Fig. 1 shows the calibration curve for resistance units of several different compositions and designs. Blocks designated by curve 1 were made with electrodes between two layers of fiberglass, then surrounded with a double layer of fiberglass and encased in perforated aluminum. Curve 2 represents the same kind of block, but using nylon instead of fiberglass; curve 3 represents blocks that were made with electrodes between two layers of fiberglass, then imbedded in plaster, as described by Youker and Dreibelbis (18). Curve 4 represents similar blocks except that the electrodes were inserted between two sheets of nylon imbedded in plaster; curve 5 represents plaster blocks made after the design of Bouyoucos and Mick (4). Curve 6 represents concentric electrode moisture plugs, made by Rayturn Machine Corp., Portland, Ore. The blocks of curve 1 were similar to the fiberglass block of Coleman and Hendrix (5), while those of curve 2 were patterned after the nylon block of Bouyoucos (2). The curves shown are the mean of 6 different blocks calibrated at different times, some of the points

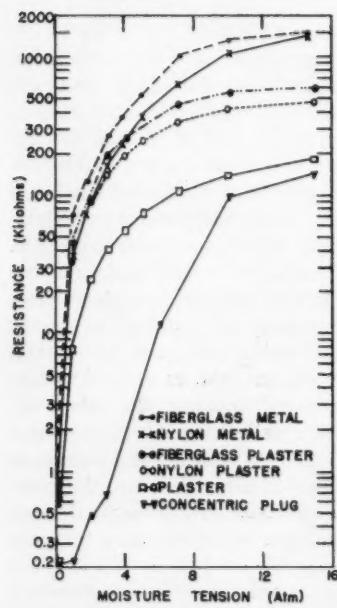


Fig. 1 Calibration curves for several resistance units for measuring soil moisture

were determined from only 4 blocks. It was not possible to get data from all blocks at all values of the pressure membrane, except in the case of curve 6 when all units were run at once. Analysis of variance was run and the standard errors for the difference between blocks treated alike was determined. Only in the cases of the plain plaster blocks and the concentric plugs with standard errors of about 12 and 15 percent of the mean was the fluctuation between blocks low enough to permit the use of a single calibration curve to apply to several blocks. The concentric plugs have very low sensitivity in the 0-1 atm range but above 1 atm, they have somewhat better characteristics than any of the others.

If the "plunging" method of Tanner *et al* (16), is used to select blocks that do not differ by more than 50 ohms, the 12 percent variation for plaster blocks can be reduced somewhat more. The blocks used in this study were selected to agree within 100 ohms by this method. Selection for uniformity of other units would undoubtedly have lowered their variance. Commercial nylon and fiberglass units have been tried. The coefficient of variation for them was not measured, but the variation was so great that different calibration curves were needed for each of the two units of each kind that were used.

The calibration curves for several kinds of moisture units are shown in Fig. 2. It is apparent that the gypsum block has somewhat lower sensitivity in the moist range. This disadvantage, however, is not great and is frequently offset by very high resistance at low moisture content with the fabric-type units. It is sometimes necessary to use a high-resistance bridge to read these units.

Potato plots 36 ft by 50 ft were handled in a uniform manner insofar as irrigation treatments were concerned. There were 8 irrigation treatments replicated 4 times, giving a total of 32 plots. Each plot was handled as a separate unit with moisture measurements being taken at 8 different locations in each plot and at depths of 6, 12, 18 and 24 in at each location. Readings were taken at weekly intervals and the coefficient of variability determined for the location, blocks themselves and the combined location and block variation. If only one set of blocks per plot had been used at ran-

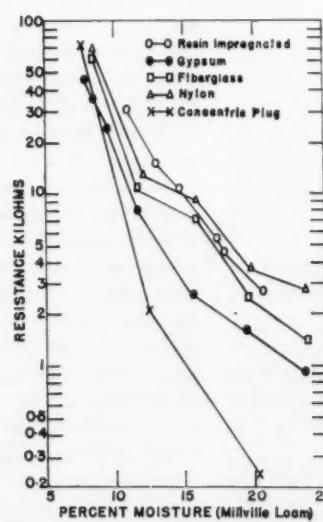


Fig. 2 The variation of resistance in moisture units in response to change in moisture content

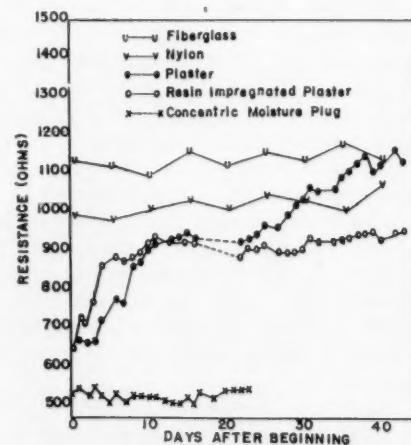


Fig. 3 The effect of alternate wetting and drying on the relative resistance of various moisture units

dom, the coefficient of variability would have been obtained by the sampling (location) precision of the plot. The variability of the blocks themselves is a measure of the precision of the blocks, while the combined location plus block variability is an estimate of the precision with which the moisture tension was measured on the plot by the 8 sets of blocks. The data are shown in Table 1.

TABLE 1. COEFFICIENT OF VARIABILITY OF MOISTURE TENSION DATA IN POTATOES FOR PLASTER BLOCKS, LOCATIONS AND PLOTS

	High tension, percent	Med high tension, percent	Med. low tension, percent	Low tension, percent	Mean percent
Location	29.2	20.5	20.4	29.1	24.9
Blocks	7.0	6.6	10.6	12.2	9.1
Plot	13.9	11.2	13.2	14.7	14.5

It is apparent that the greatest source of variation is different sampling locations themselves. This may arise from uneven soil disturbances in installing the blocks or from real differences in soil moisture that result from uneven moisture application, penetration and removal.

The source of variation among blocks themselves has been studied and found to arise largely from two sources. There is a random variation among blocks which can be minimized by selection of blocks as suggested by Tanner, *et al* (16). The blocks also tend to drift in their calibration with use. To test this, blocks are alternately wetted and dried and their wet resistance observed during each cycle.

A series of tests were made in which blocks of different materials and construction were plunged in water for 30 min at the end of which the resistance was recorded. The blocks were then allowed to dry. The process was repeated several times. The results are shown in Fig. 3.

It is apparent that the nylon and fiberglass blocks are more stable than either the plaster or the resin-impregnated blocks. The resin-impregnated blocks became considerably more stable after ten wetting and drying cycles and are equal to either the nylon or fiberglass units. The concentric electrode moisture plugs are equal to any of the units tested.

In order to determine whether or not the length of drying between alternate wettings was important a series of tests were run in which the drying period was varied from one, two or three days. It was found that plaster blocks show less change in resistance with alternate wettings and dryings when the period of drying is longer. There was no significant difference between drying for two or three days. The data are shown in Table 2.

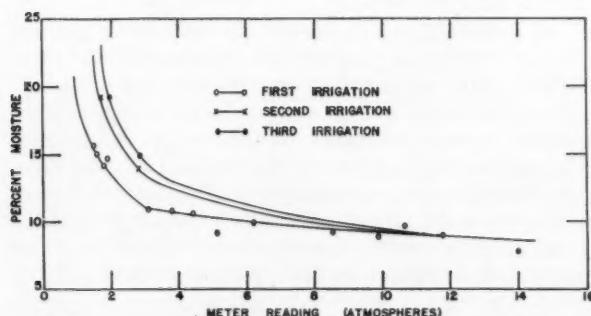


Fig. 4 Change in calibration of plaster moisture blocks in the field after successive irrigation intervals in which the blocks underwent a wetting and drying cycle. (Redrawn from Patil<sup>†</sup>)

TABLE 2. RELATIVE RESISTANCE (OHMS) IN PLASTER BLOCKS AS READ WHEN SATURATED, WITH DRYING INTERVALS OF ONE, TWO OR THREE DAYS

Drying interval, days	Number of drying intervals				
	1	2	3	4	5
1	1165	1445	1420	1305	1485
2	935	1070	1105	1200	1285
3	950	1065	1055	1170	1100

In field use, blocks are constantly being subjected to wetting and drying conditions. This results in a change in calibration and requires constant recalibration in the field if accurate results are to be obtained. U. A. Patil<sup>†</sup> made a study of the change in calibration over the entire moisture range.

In a plot ten feet square on which barley was growing, plaster blocks were placed in thirteen different locations. At each location blocks were placed at 6-in intervals to a depth of 60 in. All leads were brought off the plot to a central place where daily readings could be made. Soon after block readings were made, the soil adjacent to the plot containing the blocks was carefully sampled and moisture content determined gravimetrically. The average moisture content at each 6-in interval was determined and plotted against the average bridge reading obtained from the thirteen different blocks at that depth. It was found that the resultant curve was distinctly different for the three irrigation intervals used during the season. The results are shown in Fig. 4. These curves illustrate the seriousness of ignoring the change in calibration of plaster blocks with time.

Most plaster resistance blocks are made with two parallel electrodes located a fixed distance apart and midway between the sides of a rectangular block. With this design, many lines of electrical force extend outside the block and into the soil in contact with the block. As the nature of the soil-plaster contact changes with time, the contribution of this junction to the resistance changes, and since the contact changes in a random manner, its contribution to the resistance would likewise be random. It should be possible to correct this difficulty by building a block with large flat electrodes, such as is done in the nylon and fiberglass units or by making a unit with concentric electrodes, the outer one being made of perforated materials to allow for free passage of water. Such units have been built. The fabric units are apparently completely free of this effect. The concentric electrode moisture plug has been tested in comparison with other standard blocks of the two electrode type. External contact was varied by immersion in water, air and with three fingers holding the block. The results of one such test are shown.

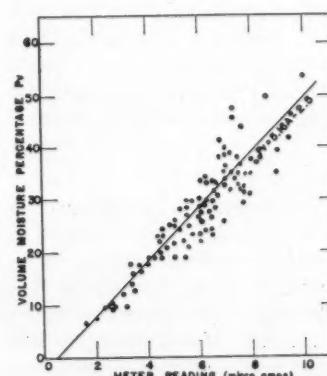


Fig. 5 Moisture content as measured from soil sampling on ten soils with variable texture as related to the neutron meter reading. The line is the calibration determined by field sampling and linear regression

<sup>†</sup>Patil, Uttamrao A. (1954). A study of the relationship between consumptive use of water and evaporation. USAC unpublished thesis.

TABLE 3. CHANGE IN METER READING (MICROAMPERES) OF MOISTURE INDICATING DEVICE AS THE EXTERNAL CONTACT IS CHANGED

Moisture unit	External contact		
	Water	Air	Fingers
Plaster	166	157	158
Resin impregnated	165	153	154
Concentric plug	173	173	173

in Table 3. It is apparent that the moisture plug has effectively eliminated the effect of external contact.

The contact between the block and the soil as well as the nature of the block itself determines the time lag in responding to moisture changes in the soil. Although no actual experiments have been performed, the contact between soil and the plaster blocks seems to be better than between soil and the fabric blocks. This is demonstrated by the fact that it is frequently difficult to get them to rewet once they have been dried out. From a very limited field experience of less than one month, it appears that the concentric moisture plug will respond very much like the plaster blocks.

There appear to be certain inherent difficulties in the measurement of soil moisture by resistance methods. The presence of salt in the soil will always introduce error. When the amount of salt is small, this might be negligible. Plaster blocks are less sensitive than fiber blocks as a result of the constant presence of a saturated solution of calcium sulfate in the block at all times. There will always be a lag in response to moisture changes; this might become negligible when the moisture capacity of the unit is small and the transmission of water across the contact boundary between the unit and the soil is rapid. None of the units used in our studies is completely satisfactory in this regard. It would appear that the concentric electrode moisture plug, as well as the nylon and fiberglass units, has completely eliminated the direct effect of external contacts on the resistance reading. The problem of shifting calibration has been reduced if not entirely eliminated. No tests have been made to ascertain whether or not the sensitivity of the moisture plug to salts has been increased by eliminating the drift in calibration.

The sensitivity of the various resistance units to changes in moisture over the range 1-15 atm is satisfactory. None of the resistance units is comparable in accuracy to tensiometers in the 0-1/4-atm range of soil moisture tension, but the fabric units of nylon and fiberglass are somewhat better than plaster blocks or concentric plugs. Resistance units can be made that are sufficiently uniform to permit the use of a single calibration curve for several units with sufficient accuracy for many field uses and for much irrigation and soil moisture research.

#### Neutron Method

It is known that hydrogen nuclei are very effective in reducing the energy and velocity of high-energy neutrons to velocities of motion comparable to thermal energies. Most of these nuclei in the soil occur in water. It should be possible therefore to correlate the scattering of thermal neutrons in the soil with moisture content. Measurements of soil water in this manner would be independent of temperature, soil texture, structure, and salt concentration. Since the effective volume on which the neutrons are scattered is appreciable, the error of field sampling might be reduced. This same factor, however, makes it impossible to determine the moisture content at any precise depth.

Several investigators have made successful determinations of soil moisture using laboratory equipment (6, 1, 8, 15). No satisfactory measurements of moisture in the field with portable equipment have come to the attention of the author.

Underwood *et al* (17) have announced a portable instrument using a large  $\text{BF}_3$  tube and a count rate meter of their own design, which in laboratory tests indicates a maximum capability within 0.1 percent soil moisture. This is apparently the resolving power of the instrument and does not include field-sampling errors, which will probably be quite large with the size and shape of tube which they were using.

A  $\text{BF}_3$  chamber filled at 35 mm of mercury pressure, and enriched with 11 percent  $\text{B}^{10}$  has been used with a portable proportional counter<sup>‡</sup> to measure the slow neutron flux. A source of 24 mc of Ra D-Be provides fast neutron flux of about 60,000 neutrons per second per square centimeter and is rated by the supplier to have a "very low gamma background."

Aluminum tubes 2.59 cm inside and 2.79 cm outside diameter were used as access tubes. They were 180 cm long and sealed at one end. They were placed in a hole in the soil made by a one inch soil auger. The moisture probe consisting of the neutron source and detecting chamber was lowered into the tube.

Moisture determinations have been made on many different soil profiles ranging from loamy fine sands to clays. Many determinations were below the water table and several soils were salted. Fig. 5 shows the results of sampling ten profiles for moisture content determined gravimetrically and for slow neutron flux. The equation for the curve was obtained from linear regression. It also shows the scatter of points for moisture determination on the profiles that varied in texture both within the profile and between the profiles from loamy fine sand to clays. The average variation from regression is 20 percent of the predicted regression value; this includes both the sampling error and the error due to gravimetric determination of moisture as well as errors due to the neutron method.

The precision of the method is not as good as can be obtained by carefully calibrated resistance units or tensiometers, but it is adequate for many purposes, being only slightly greater than sampling variations for the resistance or gravimetric methods. The method can be used in salty soils where resistance methods are not applicable. Further developmental work, however, is indicated before the method will be ready for wide field application.

#### Gravimetric Methods

In order to determine the precision with which moisture content on irrigation plots could be determined by the gravimetric method, several plots were sampled in a number of different locations and at many different depths and the moisture content determined on each sample individually. The variance due to depth was removed and all other variation was attributed to sampling error. The standard error of a sample was determined and calculated as a percent of the mean moisture content. Samples were taken before irrigation and after irrigation on both sprinkler-irrigated and fur-

<sup>‡</sup>Both items were obtained from Nuclear Instrument and Chemical Corporation and are known by the trade name DN-1 thermal neutron detector and the model 2111 Pee-wee proportional alpha counter.

row-irrigated plots of potatoes. The errors reported were for determination on a single plot that received water as uniformly as it was practicable to apply it with the methods used. The soil used was Millville loam which is considered to be a uniform soil in so far as observable physical and chemical properties are concerned. The results are shown in Table 4.

TABLE 4. THE STANDARD ERROR OF SAMPLING SOIL MOISTURE GRAVIMETRICALLY AS A PERCENT OF THE MEAN SOIL MOISTURE FOR FURROW AND SPRINKLER-IRRIGATION PLOTS BEFORE AND AFTER IRRIGATION

	Furrow	Sprinkler	Mean
Before irrigation	13.8	29.0	21.4
After irrigation	16.6	19.9	18.2
Mean	15.2	24.4	19.8

This error is quite large and is of equal order of magnitude with the errors found in the resistance and neutron methods for measuring soil moisture. The standard error for determining soil moisture in the surface six inches of soil 24 hr after a heavy uniform irrigation was 7.4 percent of the mean, which is better but still quite variable.

#### Relative Precision of Methods

Three methods have been used sufficiently in the field to assess their precision with respect to their capacity to indicate the moisture content of a plot. The precision obtained from a number of measurements per plot has been calculated and the values indicated for one, two, four, and eight measurements in Table 5.

TABLE 5. THE PRECISION OF SOIL MOISTURE MEASUREMENTS OBTAINED BY VARIOUS METHODS WITH DIFFERENT NUMBERS OF SAMPLES PER PLOT

Number of measurements	Coefficient of variability, percent	Plaster blocks	Neutron method	Gravimetric method
One	24.9	20.1	19.8	
Mean of two	17.5	14.2	14.0	
Mean of four	12.5	10.1	9.9	
Mean of eight	8.4	7.2	7.1	

Precision measures only the reproducibility of the method. The accuracy depends upon detailed and accurate calibration of the instruments.

In terms of time, 80 to 100 resistance measurements or about 20 neutron measurements are equivalent to one gravimetric determination. If we can assume that the calibration curves of the resistance units are known and accurate at all times, the moisture content or tension could be measured with more accuracy with only two measurements per plot than with one gravimetric determination. Two measurements with the neutron method would also be better than one gravimetric measurement. If it is necessary to distinguish between plots whose mean difference is only 10 percent, it will be necessary to use either eight resistance blocks, five neutron determinations or four gravimetric measurements in each plot.

#### Discussion

The large errors reported in field studies with tensiometers, resistance units, neutron method, and gravimetric sampling is largely a result of real variation of moisture in the field. Water is removed unevenly by plants, so that in some parts of the plot water is removed to lower depths and to greater extent than in other parts. A random sampling picks up these variations.

Uneven application of water may greatly contribute to unequal distribution in a plot. Even though water may be

applied more or less uniformly at the surface, any cracks, discontinuities, marked changes in structure or texture cause unequal water penetration and distribution.

Some soils will be more or less variable than reported, but unless some means is found for reducing or eliminating many of the factors causing variation, it is unlikely that the coefficient of variability for field sampling of moisture plots can be reduced much below 10 percent.

In order to determine accurately the moisture content of any plot or field at any time, a large number of samples should be taken. Fewer samples are required for the gravimetric method than for the resistance or neutron methods in order to give any desired degree of precision.

Tensiometers will indicate moisture tension over the range in which they operate with about the same precision that the gravimetric method will indicate moisture content.

When resistance methods are used to indicate either moisture content or moisture tension, precautions must be taken to be sure that the soils are not saline and that the proper calibration curve for the block at the time is used.

The neutron method is approaching the accuracy and precision of resistance units and has distinct possibilities of being more accurate than any other method tried.

None of the presently available methods of measuring soil moisture in the field are completely satisfactory. Further work and research in developing methods to give smaller sampling and instrument errors are needed.

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# Lubricants As Engineering Materials

N. A. Sauter

MANY people feel that the subject of lubrication is overworked and advertising in newspapers and magazines gives much evidence that seems to justify this contention. Much is implied but actual differences between lubricants sometimes are hard to find. The purpose of this paper is to present some illustrations that identify these differences and to describe some of the means for tracking them down. Also, the paper will be restricted to lubricants for farm implements rather than for tractors, in order to avoid discussion of motor oils and transmission lubricants.

The field of agricultural engineering has many problems, brought about by building complex and highly automatic mechanisms to be offered to the public at competitive prices. This trend has a distinct effect on the lubricants required. While the designer wants to develop a machine that is tolerant of lubricants which might be used, he often finds that the use of a special lubricant can simplify the design and reduce cost.

When it is recognized that the film of lubricant which must be present has a specific engineering function, the matter of defining and testing comes into better perspective.

All lubricants can be divided into three types: Solid, liquid, and plastic or grease.

## Solid Lubricants

The solid lubricating elements are usually suspended in oil or grease, but essentially the solid matter is performing the job of lubrication. The most common of these solids is graphite, and the most spectacular is molybdenum disulfide. There are others, however, such as zinc oxide, mica, and titanium dioxide. In general, these materials form a solid barrier between mating surfaces and, in so doing, possess a great ability to withstand pressure and to resist being rubbed

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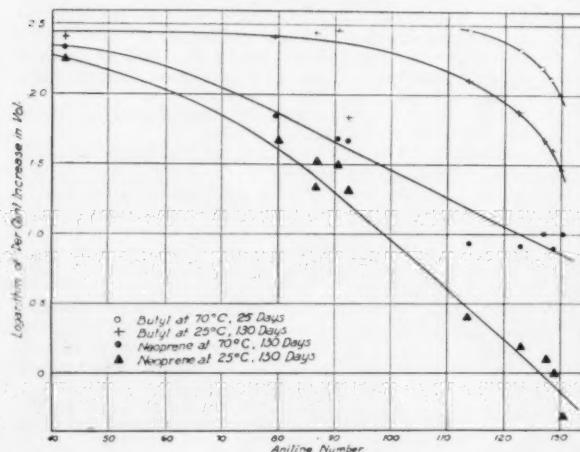


Fig. 1 The effect of aniline point of oil on swelling of synthetic rubbers

Lubrication engineer points out differences in farm machinery lubricants and explains how lubricant characteristics influence implement design and can be considered as engineering tools

off. Solid lubricants are used for the following applications:

1 Where loads are not particularly high, but where a form of permanent lubricant is required.

This application is used in lubricating the rockshaft of certain tractors and such mechanisms as latches and linkages. While it is not widely used, it would seem this method is applicable to implement chains. Soaking the chain would be required to insure penetration at the point of wear between the pin and bushing.

2 Where there are high unit loads and some break-in is required.

In this type of application, solid lubricants are used by the factory for initial lubrication, while conventional lubricants are satisfactory for use in the field. Examples of this type of application are ball-and-socket connections where, because of the geometry involved, contact areas are small and unit pressures high. Actual applications are newly assembled clutch fingers and the ball-and-socket connection for hitching a carry-all scraper to a track-type tractor. This method is also used in lubricating the breakaway plow standard manufactured by our company.

3 Where there are high temperatures.

Solid lubricants are commonly used in high-temperature applications, but this is not a consideration in the field of agricultural implements; it is mentioned only for the sake of completeness.

Solid lubricants have certain limitations that should be kept in mind. For one thing, graphite which is commonly used has within it a certain amount of abrasive material; for another, with prolonged use, the solid particles tend to build up in clearances and lubricant grooves.

## Liquid Lubricants

The second class of lubricants, described as liquid, include not only the most common, which is petroleum oil,

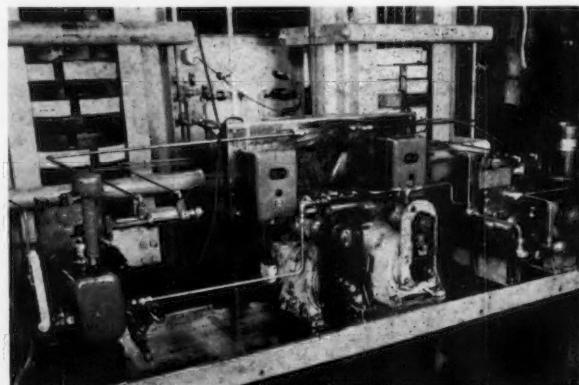


Fig. 2 Hydraulic test stand with automatic temperature control and automatic cycling for studying oil requirements and performance of hydraulic systems

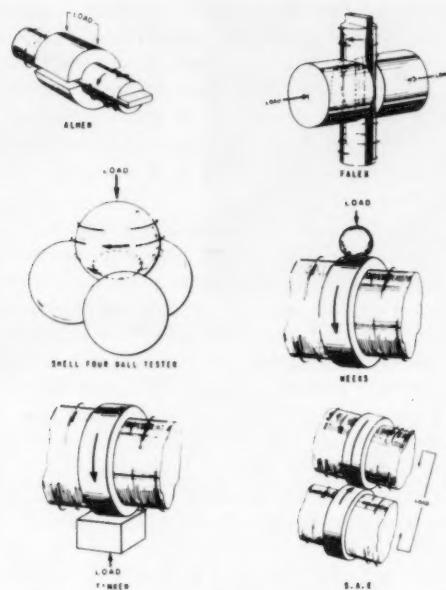


Fig. 3 Principles of operation of common types of extreme-pressure oil-testing machines

but also silicone and synthetic oils. At the present time agricultural implement requirements can be covered adequately by petroleum oils; however, the designer should be aware that petroleum oils are not the only liquid lubricants. Other than motor oil, the most important oil in the agricultural industry is the hydraulic oil.

**Hydraulic Oils.** Aside from the usual requirements of hydraulic oil, that it should not thicken excessively when it is cold nor thin out excessively when it is hot (viscosity index) and have long life with resistance to gumming of valves (oxidation stability), it should have a negligible effect on the rubber components which may be included in the system. As an indication of this effect, the aniline point of the oil is important. This is ASTM Test No. D611-53T. The most common material for making rubber components for hydraulic uses is neoprene which, for the most part, is not affected by oil. However, in Fig. 1 is shown a curve of the effect of aniline number on the swelling of neoprene and butyl rubber, indicative of the fact that, while neoprene is relatively unreactive, it is not totally inert. Fortunately most oils in common use today do not go much below an aniline number of 100c; and 75c is considered marginal. Some companies find it necessary, however, to specify an aniline number in certain applications. This is being done at least by one farm equipment company in the case of hydraulic oils and by another manufacturer in the case of track-roller grease.

In studying the oil requirements for one particular type of tractor track roller, it was found that the high-aniline-number oils tend to make the seals brittle while the softening effect of the low aniline oils seems to be desirable. This perhaps is a good illustration of the need for studying the individual requirements rather than to deal in generalities. A test factor which seems to be important is to have rubber of equal age and preferably from the same batch, as some variation from batch to batch can be expected. In view of the trends in the refining of oil to a greater degree, it seems

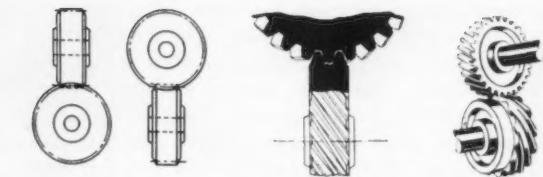


Fig. 4 (Above) The geometry of frictional rolling surfaces and crossed helical gears

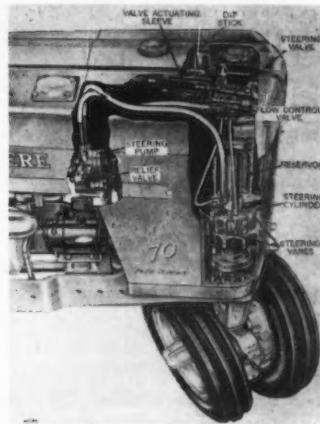


Fig. 5 (Right) Cutaway view of power-steering system

wise to be cautious about rubber components.

In Fig. 2 is shown a hydraulic test stand used by one of our company factories not only to study the oil requirements of the hydraulic system but also to study the performance of the various elements that comprise the system. This approach, while more time-consuming and costly, seems to be one of the best methods of evaluating hydraulic oils for farm equipment.

**Extreme Pressure Oils.** Another property of oil that sometimes is utilized in implement design is the matter of load-carrying capacity. The petroleum industry uses several types of test machines to measure this property. In Fig. 3 the geometry and principle of operation are shown for each of these machines. These test procedures, being accelerated, give results that can be interpreted only in terms of background experience with the particular machine and with the type of application to which the test is applied. These oils are known as extreme pressure (EP) oils and in general are classified into three types:

1 Extra oiliness or lubricity type. In this type sulfurized lard oil or its synthetic equivalent is added to mineral oil. Phosphorus compounds are sometimes used for this purpose. This type is generally considered non-corrosive.

2 Mild EP type. Lead soap is usually added to oil containing some reactive sulfur so that relatively thick adherent films of lead sulfide are formed under high pressure or temperature. This type also is considered non-corrosive.

3 Full or powerful EP type. In this type sulfur, chlorine, phosphorus and lead are added to oil in various combinations so that, under pressure and heat, sulfur reacts to form iron sulfide and chlorine reacts to form iron chloride. This class is recognized immediately as the corrosive hypoid type.

There are examples of applications of the latter two grades in the implement industry. The full EP type is being used on enclosed crossed helical gears. In Fig. 4 the geometry of the rolling surfaces and of the gears generated from the surfaces is illustrated. It is apparent from these draw-

ings that there is point contact between the gears and also a high unit loading. Where loads are light, the lubrication of gears of this type does not present a problem to the designer. However, when these gears have to transmit appreciable power, there is an almost impossible situation, for no matter how large the gears are, there is still a point contact and high unit loads. The full EP oil has fitted into such applications in the farm implement industry. The anti-weld effects arising from the use of this type no doubt account for the success of such designs in the field. It is likely, however, that the mild EP type could do an equal or better job because of its ability to form thick, tenacious films which would have the effect of spreading out the area of contact.

Another interesting application where a designer has utilized the performance properties of certain mild EP oils is the development of the John Deere power-steering unit. In Fig. 5 is shown a cutaway view of the hydraulic system. The lubricant in this system must serve not only as a hydraulic medium but also must lubricate the worm gear. The nature of the design is such that the worm gear does not have a lot of work to do, but it is important that it be properly lubricated. The designer has at least two options from which to choose. He could separate the worm-gear compartment and use two lubricants — each to do its special job—or he could use one special oil. The latter was selected in order to avoid the problem of sealing the wormgear compartment and to achieve to a fuller extent the concept of a power-steering unit. Certain precautions must be used in adapting mild EP oils to hydraulic service, because they do not always have the oxidation stability that may be required.

**Rust-Preventive Oils.** Protection against rusting is another property associated with oil and which the designer can utilize to his advantage. In the lubrication of cotton-picker spindle bearings, for example, the problem is that the spindles are wet with water, or water containing a wetting agent, so that there is a tendency for the oil to be washed out of the bearings. In operation, an emulsification of oil by a wetting-agent solution occurs. In laboratory tests it seems that the wetting agent is a big factor in controlling rust on the spindle bearings. At this writing it is not certain exactly

what properties the oil must have; however, it appears that ability to emulsify slightly is more favorable than extreme resistance to emulsification. Good inherent rust resistance as measured by humidity cabinet tests also seems desirable. This application is a good example of the cooperation of the petroleum industry with the farm-equipment industry in developing an entirely new oil to insure proper operation of a new machine.

**Additives.** The use of oil additives is a phase of lubrication which is a subject in itself. An additive is something which is added to oil to enhance its properties in one respect or another. Common additives are rust and oxidation inhibitors, detergent and tackiness additives, viscosity index improvers and EP additives. In the steel industry materials of this type are known as alloys. The most widely known use of additives in oil, of course, is in motor oils. On the whole, these oils are very suited to implement needs; however, they may have certain limitations when applied through sintered metal bearings in that certain types of additives have a tendency to be filtered out thereby blocking further passage of oil. For this reason and also because oil may not be perfectly clean as it is applied to the bearings, it would seem a safer practice for the designer not to lubricate through the bearing, but rather through the end of the bushing or by drilling a hole to insure getting oil directly to the frictional surfaces. For the same reasons, it is preferred not to use grease- or soap-thickened oils as the soaps tend to clog the pores. Non-additive oil applied from a clean container is the safest lubricant where oil must go through the bushing.

#### Plastic or Grease Lubricants

The third class of lubricants, described as plastic or grease, presents a complex situation today. Formerly greases could be described as oils containing soap. This definition is recognized as incomplete because detergent oils also contain a type of soap, and many greases on the market do not contain any soap. Therefore, the ASTM currently defines grease as follows: "A solid to semifluid product of dispersion of a thickening agent in a liquid lubricant. Other ingredients imparting special properties may be included." The "other ingredients" are additives and inhibitors of the type used in oil. Thus today we find two basic types of grease: the soap-thickened type and the gel type. In this connection it should be pointed out that greases are also being made today from synthetic oils.

The more common soaps used in grease are sodium, calcium, and aluminum. Lithium soap greases have become prominent in recent years, with lead and barium also in the picture. Among the gel-type greases, the most widely known are those derived from silica gel and bentonite.

Formerly it was said that greases made from soda soap were fibrous, had a high melting point, and were not water resistant. Also, it was said that lime-soap greases were

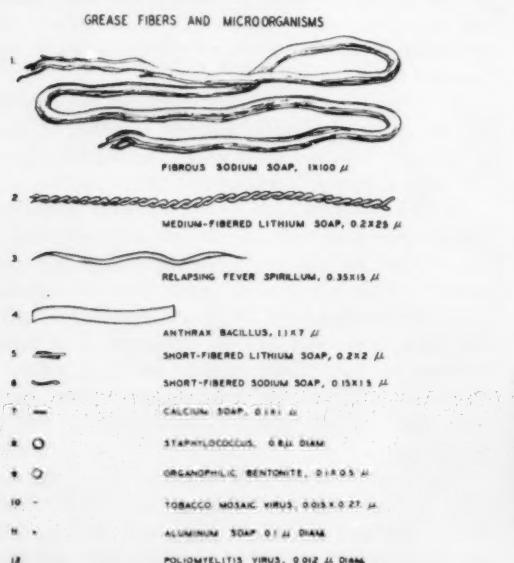


Fig. 6 Comparative sizes of grease fibers and microorganisms



Fig. 7 Micrographs showing fibers in lubricating grease. (Left) Short fibers • (Center) Medium fibers • (Right) Long fibers

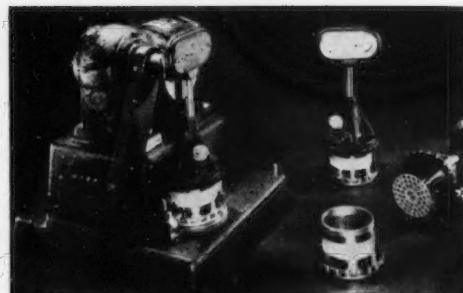
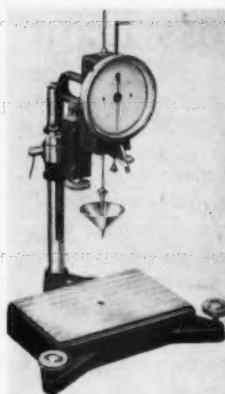


Fig. 9 (Above) Motor-driven ASTM grease worker

Fig. 8 (Left) Penetrometer for measuring grease consistency

smooth, had a low melting point and were water resistant. The picture today is that there are smooth soda-soap greases with good water resistance and high-melting-point lime soap greases that are fibrous.

Because the word "fiber" seems to be misleading, Figs. 6 and 7 show examples of the fiber formation that the soap in grease may assume. One theory is that the fibers hold the oil in place and give the thickening effect. The fibers are formed as a natural result of the manufacturing process and the type of soap used. Fiber lengths can be shortened by putting the grease through a colloid mill which mechanically breaks down their length. Thus there are the terms long and short fiber grease, and smooth, buttery type. The study of fibers by means of the electron microscope is being done widely today at the research level.

In Fig. 8 is shown the penetrometer used by a grease chemist to measure the depth of penetration of a specified cone into the grease. In Fig. 9 is shown a grease worker which is used to provide mechanical working and to study resistance to softening. Formerly 60 strokes in a worker such as this was considered "worked penetration". However, today with the development of greases having much better resistance to softening, due to mechanical action, working the grease 100,000 strokes is not uncommon.

In Fig. 10 are illustrated the differences between greases when they are worked mechanically. It is apparent that each of the greases plotted has a different characteristic. Grease A has reached a plateau and it would seem constant; grease B shows a tendency to soften gradually; grease C shows a tendency to soften rather quickly and then a tendency to level off, while grease D seems to get progressively softer.

Another type of tester used to measure mechanical stability is the Shell roll tester shown in Fig. 11. The roll tester consists of a slowly rotating cylinder containing a steel bar

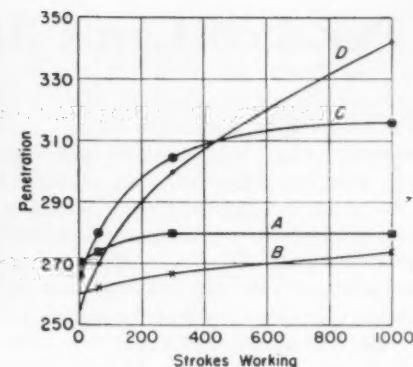


Fig. 10 Penetration (consistency) change with amount of working in ASTM worker for typical types of lubricating greases

that kneads the grease. Later modifications slow down the rate of rotation and apply heat during the test.

The designer knows that, if a good seal is provided and if the finish on the shaft is good enough, almost any grease can be retained regardless of its mechanical stability. Under production conditions, this ideal situation is usually too

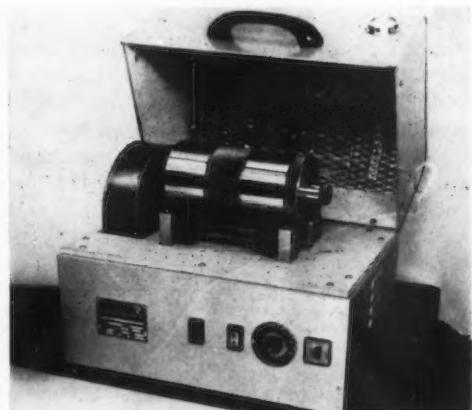


Fig. 11 Shell roll tester for measuring mechanical stability

costly to obtain. However, by utilizing stable greases the seal and shaft finish requirements may not be so critical. In studies of this problem, using the same shaft and seal, leakage from a gear case could be reduced from about 40 percent in 8 hr to almost nothing in 100 hr. The type of apparatus used to make this study is shown in Fig. 12.

(Continued on page 666)

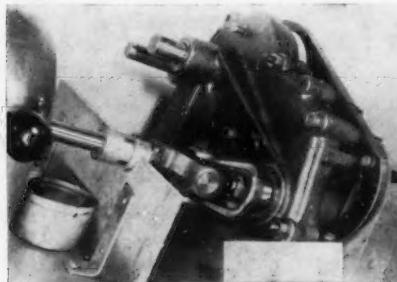
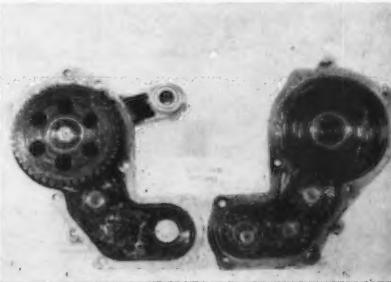


Fig. 12 (Left) Test stand for studying grease leakage • Fig. 13 (Center) Conventional soda soap grease showing separation of free oil and the formation of soap deposits • Fig. 14 (Right) Grease having good mechanical stability



# Punched Cards Record Runoff and Soil-Loss Data

W. H. Wischmeier

THE task of summarization and analysis of extensive runoff and soil-loss data through the medium of punched-card techniques is, in many respects, a pioneering job. Such a summarization project has been recently initiated at Purdue University in the Soil and Water Conservation Research Branch of the Agricultural Research Service (ARS) U.S. Department of Agriculture in cooperation with all the state agricultural experiment stations where runoff and erosion data have been collected during the past quarter century. The project is the result of recommendations by a group of leaders in soil and water conservation work (representing the ARS, the Soil Conservation Service, a number of state agricultural experiment stations, the U.S. Weather Bureau, and the U.S. Bureau of Public Roads) who met at Ames, Iowa, in June, 1953.

The purpose of this discussion is to present a picture of the quantity and type of data available. Methods in which the processed data may be profitably used by others working in research, land use, drainage, structure, flood control, irrigation, and related fields will be suggested.

## Available Data

The data currently being summarized were collected at 35 widely-scattered soil conservation research projects, now the responsibility of the ARS, in cooperation with the state agricultural experiment stations. (See Fig. 1)

Precipitation data are included for approximately 65,000 individual storms, representing about 530 location-years. Runoff and related data cover about 8,250 plot-years and 2,500 watershed-years. Soil losses were measured from the plots and from some of the watersheds. Peak rates of run-

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Urbana, Ill., June, 1955, on a program arranged by the Soil and Water Division.

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Fig. 1 Circled dots indicate location of widely-scattered soil conservation research projects cooperating in the new summarization project

*Runoff and soil-loss data, collected during the past quarter century, are being gathered from soil and water conservation research stations in the various states. These data are edited, coded and recorded on punched cards as part of a new (ARS) program conducted by the U.S. Department of Agriculture. Electrically-controlled machines run these cards, process the data and print specified results in a readily-used form*

off are included for the watersheds and for those of the plots which were equipped with recorders. Only single-crop watersheds are included in the present summarization.

For 5 of the 35 locations reporting, the period of record exceeds 20 years, and for 21 locations it ranges from 10 to 20 years. Nine projects reported less than 10 years' data.

It is planned that current data will be added annually from about 425 plots and 92 small watersheds still under measurement at 16 locations.

## Procedure

Objectives of the project are: to make this large volume of basic runoff, soil loss, and related data available in the application of current methods of hydrologic analyses and in the development of new and improved methods of analyses; and to stimulate application of these data to the solution of problems confronting field technicians and farmers.

Attainment of these objectives requires that the mass of basic data be preserved in a compact and readily available form at a single location. Data at different stages of analysis in 35 widely scattered locations are not readily available for use other than at their original source. Through the closing out of research projects, some valuable data have already become extremely difficult, if not impossible, to locate.

Units of measurement and the form in which data are recorded must be standardized. For example, some stations were recording runoff in inches, some in gallons, some in cubic feet, and others only in percent of rainfall. Comparisons of data in such a variety of units become extremely cumbersome. Units adopted for the summarization are: precipitation on individual storm basis, runoff in inches, and soil loss in tons per acre.

Large volumes of data can be organized and summarized efficiently through the medium of punched-card techniques. This method of recording data results in a unique kind of record which can be used to produce, in machines designed to process the data automatically and rapidly, a wide variety of statistical analyses. The machines run cards through, process the data punched into them, and print the desired results electrically, in strict accord-

ance with directions wider into a control panel. Once the data are accurately transferred to the cards, chances for error are indeed small. Numerals do not become obliterated and can be read by the machine at only their correct value.

Basic data tabulated at the field locations on standardized forms or tables are sent to the central office at Purdue. There they are edited, omissions and obvious errors corrected through correspondence with the field personnel, descriptive data coded to adapt them to punched-card techniques, and the processed data transferred to IBM cards.

Purdue University maintains a technical counseling service of skilled mathematical and applied statisticians who work as committee members, specializing in particular fields of application. Design and interpretation of analyses in the central office at Lafayette are in close cooperation with these consultants.

Four basic cards, as described below, have been designed for recording the original data. Common identification of the experimental area and storm number in each of the four cards will insure of the sets for any combination of the

*Card No. 1 Plot or watershed description.* A card for each plot or watershed for each study provides information on plot dimensions, soil type, slope, depth of topsoil, variables studied, cropping practice, soil treatments, row direction, disposition of residues, special conservation practices, type of measurements, and years of record. Cropping information is organized to permit ready sorting either on a general cover basis, such as row crops, or on a specific crop. Data for second-year corn and data for soybeans following one year of corn, for example, could be segregated easily by mechanical sorting of these cards.

*Card No. 2 Precipitation data.* This deck contains a card for each storm during the entire period of record. A period of 1 hr with less than 0.01 in of precipitation is considered a break between storms. Individual storms are identified by numbers assigned in chronological order on a calendar-year basis. The card reports the date of the storm, duration, amount, maximum intensities for 5, 15, 30, and 60 min, and energy content of significant storms. Excessive-rate storms are classified as advanced, intermediate, or delayed. It is planned that antecedent rainfall information will be added by summary punching.

*Card No. 3 General data card* (Fig. 2). This deck will contain one card for each runoff-producing storm for each plot or watershed on which measurable runoff occurred. The card reports runoff and soil loss data, together with pertinent precipitation data and information on related factors as they existed at the time of the storm. These factors include type and condition of land cover, beginning and ending dates of current cover or crop period, number of days since last tillage of the soil, runoff-producing rains

Fig. 2 Descriptive data are adapted to cards by numerical coding. The holes in this General Data Card from the project files provide the following information:

Card Columns	Interpretation
1 to 4	Card No. 3; region, Midwest; state, Iowa; project, Castana
5 to 9	Area identification, series 1, plot 1
10 to 11	No freezing temperatures date of storm nor during preceding 5 days
12	Storm was excessive-rate
13 to 16	(Reserved for equivalent energy of storm)
17 to 28	Maximum intensities 4.95, 4.69, 3.88, and 2.84 in./per hr for 5, 15, 30, and 60 min, respectively
29 to 40	Storms No. 55 and 56, June 18, 1951
41 to 57	3.50 in precipitation, 0.88 in runoff, peak rate not measured, 1.43 T/A soil loss
58 to 75	At time of this storm, plot was in row crop, specifically corn, preceded by winter cover crop turned under April 18; less than 30 days since planting corn on clean fallow; 12 days since last tillage of soil; erosion had occurred since last tillage operation; no crop damage by insects or disease; soil treatments conventional; farmed on contour; cornstalks remained on area through December 31
76 to 78	(Reserved for antecedent moisture data)

since last tillage, crop damage by insects or disease, last preceding cover, disposition of residues, soil treatments, and mechanical conservation practices.

Card No. 4 provides detailed information on those storms which qualify as excessive-rate under the U.S. Weather Bureau definition:  $(0.20 + 0.01 t)$  inches in  $t$  minutes.

## How the Data in Punched Cards Can Be Used

*Organization of data for statistical analysis or for presentation in summary form.* Arranging data into desired sequences (such as chronologically, in order of magnitude, or according to some physical characteristics) and grouping large quantities of values into classes are simple machine processes. Data may be interfiled into a desired relationship with other data at a rate of between 240 and 480 cards per minute.

*Printing for presentation.* Data organized by arranging and interfiling can be printed (listed) by the tabulator. For instance, from 25 years of records on a set of rotation plots, the minimum soil losses or runoffs could be selected, arranged in order of increasing magnitude, and printed by the tabulator, together with any of the related information punched into the cards.

*Selection of specific information from large quantities of data is possible at the rate of 450 to 650 cards per minute.*

*Determination of the extent of available data taken under a complicated combination of conditions is a rapid mechanical process. As a simple illustration, suppose an estimate is desired of the relative peak rates of runoff from land in contour-farmed row crops, small grain, and meadow to be expected for a given soil type and slope combination. By mechanical sorting, cards can be selected for*

all plots meeting these five conditions: peak runoff rates available; reasonably similar soil types; comparable slopes; in a row-crop—small grain—meadow rotation, with all crops represented each year, and farmed on the contour. The selected cards can then be classified according to soil types and the applicable data on peak rates of runoff mechanically arranged for analysis and significance tests.

A flood-control engineer may be interested in making an intensive hydrograph study of a few storms with exceptionally high maximum intensities recorded for plots or watersheds in a specific crop cover. A routine sorting would bring out the cards for all storms in the records which met the qualifications he specified, and detailed hydrograph information could be supplied by photostating tabulated records in the central files of those storms.

These rapid selections enable one to determine where and when studies have been conducted in which the data collected were of such a nature that they could serve as a basis for design of a specific new study or as supplemental information to assist in interpretation of local data.

*Complicated mathematical computations* can be performed by machine directly from the data punched into the cards and results printed or punched into summary cards.

When the volume of data is large, such computations as obtaining sums of squares, cross products, regression coefficients, and the solutions of simultaneous equations can be performed accurately and swiftly by passing the selected cards through properly "instructed" computing machines. If the number of observations available for an analysis is found to be small, the values may be read manually from the selected cards, or printed by the tabulator, and computations performed on a desk calculator.

In the interpretation of studies conducted over a period of years at one location, it is highly desirable to know how well the measured sample of the weather variable fits into the local long-range pattern with regard to amount, distribution, and inter-sities. Normalcy tests are planned for the periods of measurement.

In agricultural experiments rigid control of all extraneous variables is not possible and would not be desirable if it were possible. But in a well-designed experiment the effects of extraneous variables are handled in such a way that they do not bias resulting data. Careful design often will provide full information on numerous main effects and their interactions at no greater cost than a poorly designed study of a single main effect. It will also give the experimenter a definite measure of confidence he may attach to the results.

It is recognized that the application of current statistical techniques to data already collected in past studies will present many difficulties. But this mass of data undoubtedly contains a wealth of available information which will be helpful in answering questions confronting field technicians and farm planners. Many analyses will be possible on a local basis. Comparable data from several locations may be combined for analysis if the experimental errors are homogeneous. One approach would be to try to confound soil type and rainfall effects with blocks in an incomplete block design. In some instances, the management and characteristics of a plot at one location may have been nearly enough identical with those of a plot at one or more other locations to serve as a check plot for comparison of areas under other treatments at these locations. Interpretation of scanty data

from one state may sometimes be augmented by information available from other locations.

Single numerical evaluations of rainstorms and antecedent moisture conditions, if such are feasible, would greatly increase the value of the organized data by facilitating comparison of runoff or soil loss from crops grown on plots with identical physical characteristics and treatments, but in different years or at several locations. Efforts are under way to find a method of computing such a single numerical evaluation of a storm which would include at their proper weights the effects of its total amount, duration, and various intensity components.

Attempts are also being made to determine a good prediction equation for soil loss or runoff to be expected from untreated fallow soil of specific type and slope. Computed values based on this equation will then be applied to data from other plots to determine the effects of various soil treatments, covers, and management practices on erosion and runoff.

It is planned that results of analyses and partial summaries of the data will be published. Everything possible will be done to make specific data available in organized form to other federal agencies and state experiment station personnel who wish to use them. This could be in the form of printed tabulations, or for those who have punched-card facilities available, it could be duplicate sets of cards. As indicated earlier, this is a pioneering job in this field. It involves the development of new techniques. Progress will depend on the rate, accuracy, and completeness of data supplied by each state and upon the funds that can be made available for carrying out the project. Suggestions as to specific analyses of these data that may help to supply answers to questions in soil and water management will be welcome.

## Lubricants As Engineering Materials

(Continued from page 663)

In Fig. 13 the results obtained from a conventional soda-soap grease are shown. The soap deposits are apparent in the gear area and likewise in the pool of free oil in the lower left-hand portion of the case. Using a grease having a high degree of mechanical stability, results of the type shown in Fig. 14 can be obtained. There may be a hazard in using greases of this type in that, by nature, they are not tenacious and as a result do not form thick films as do greases with lower mechanical stability. This effect, however, can be readily appraised.

It is the author's opinion that greases of this type have application in ball bearings, and in certain types of gear cases where the grease is to be retained over a long period of time, perhaps for the life of the machine. Caution should be exercised in the case of roller bearings. The designer can visualize the great assistance that can be given to a seal for the retention of lubricants and the exclusion of dirt by greases that exhibit a high degree of mechanical stability. Lithium-soap greases, stabilized or anhydrous lime-soap greases, special soda-lime greases and the non-soap greases seem to possess this property. Today the trend toward wider distribution of better greases to the farm trade seems to be established not only upon the ability of these lubricants to do a better job but for their suitability as multipurpose lubricants as well.

# Aeration of Stored Grain

Leo E. Holman  
Member ASAE

ONE of the problems of grain storage which has received considerable attention for several years is moisture migration and moisture accumulation in stored grain. This problem will continue to receive attention, both in government storages and in commercial facilities.

It has long been known that accumulations of moisture occur in the top layers of stored grains during the fall and winter months, particularly in the more northerly, colder regions of the United States. Until about 1943 it was thought that the damp grain found in the surface layers of stored grain was caused by water or snow leaking into the bin or by high atmospheric humidity. Storage studies under way at that time in the U.S. Department of Agriculture indicated that the excessive moisture accumulations were due, at least in part, to moisture migration within the grain mass. Temperature differences show up within a grain mass during the fall and winter where grain is stored in large bulks. Grain near the bin wall and surface cools faster than grain in the bin interior. The difference in grain temperatures is responsible for convection currents which move downward through the cooler grain near the bin walls and upward through the warmer grain at the bin center. There is a slow but continuous exchange of moisture from the warmer to the cooler grain due to differences in vapor pressure. This moisture tends to move upward because of the effect of the rising convection currents taking place within the central portion of the grain bulks. As the warmer, moist air reaches the cooler grain near the surface, condensation generally takes place to a degree depending upon the conditions of the grain and the atmosphere. Some molding and caking of the surface grain often accompanies this accumulation of moisture.

The relation of temperature differences, convection currents, and moisture migration in stored grain was clearly demonstrated in an experiment conducted at Ames, Iowa, in 1943-44, in a 2,740-bu circular metal bin filled with shelled

Temperature records of wheat stored in ships reveal that aeration, as a method of equalizing temperature of the grain mass by cooling (not necessarily drying), reduces accumulations of moisture in the top layers of stored grain during fall and winter months

corn. Results of this experiment were reported in a paper entitled "Mechanical Ventilation of Stored Grain," by Robinson, Hukill, and Foster, in *AGRICULTURAL ENGINEERING* for November 1951. Later investigations have provided further proof that moisture migration also occurs in stored soybeans, wheat, and other grains and that it is more pronounced as the size of bin increases.

Studies made on grain stored at government-owned bin sites provide considerable proof that aeration of stored dry grain is desirable and practical. For the purpose of this discussion aeration is defined as "the circulation of small volumes of cool, atmospheric air through stored grain for the purpose of cooling the grain to prevent moisture migration and to minimize microflora and insect activity." The distinction made here between aeration and drying with unheated air is that air-flow rates for aeration are less than 1 cfm of air per bu as contrasted with rates ranging from 1 cfm per bu upward to 10 cfm, or higher, when drying with atmospheric air.

Aeration as defined here is not intended as a method of drying grain; in fact, it may increase the grain moisture at times. Aeration is a method of cooling the grain to equalize the temperatures of a grain mass and thus eliminate the convection currents which are responsible for moisture migration and subsequent moisture accumulations.

By preventing high moisture accumulations, caking and molding of surface grain is minimized, which also minimizes to some extent any insect activity in these areas.

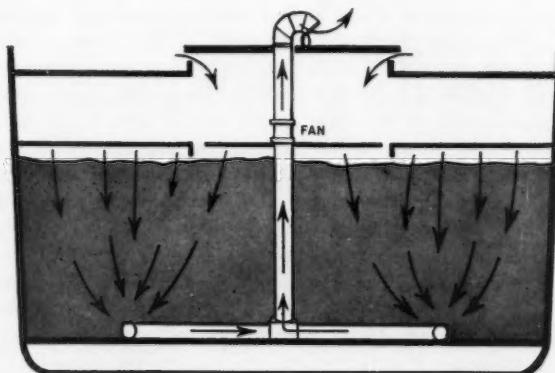
In aerating stored grains, fans are generally operated to draw the air downward through the grains. This is done for two reasons: it tends to offset the natural tendency of the convection currents to move upward from the warm grain toward the cool upper surface; and the exhaust air, which is generally comparatively warm and moist, is expelled through warm grain in the lower part of the bin and not through the colder upper grain surface where some condensation might occur.

As early as 1949, fans for aerating stored grain were installed in government-owned storage buildings holding from 20,000 to 40,000 bu. The fans circulated at least 0.1 cfm per bu through the grain. A  $\frac{1}{4}$  to  $1\frac{1}{2}$ -hp electric motor provided sufficient power for operating the fan which was connected to a central perforated floor duct. Air was drawn through the grain, into the duct, and exhausted through the fan. The time required to cool the grain to a comparatively uniform and cool temperature ranged from 3 to 10 days depending on atmospheric conditions, size of aeration unit, and the initial temperature of the grain.

In 1951, tests were started at Ames, Iowa, using a second type of system for aerating stored grain. This system is dis-

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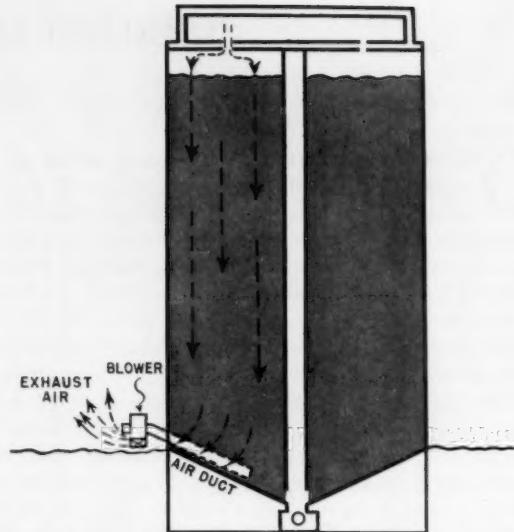


An aeration system in which  $\frac{1}{3}$ -hp fan delivers  $\frac{1}{40}$  cfm per bu to aerate 40,000 bu of wheat stored in one of 5 holds of a Liberty ship

cussed briefly in a paper entitled "Grain Cooling By Air," by W. V. Hukill, in *AGRICULTURAL ENGINEERING* for July 1953. A 4 to 8-in-diam pipe or tube is inserted vertically to a depth of about 9 ft in the grain at the center of a 3,200-bu circular bin. The lower 6 ft of the pipe is perforated. A small centrifugal or propeller-type fan is mounted on the upper end of the pipe. The fan delivers from  $\frac{1}{20}$  to  $\frac{1}{50}$  cfm per bu and is driven by a small fractional-horsepower electric motor. Air is drawn down through the grain, into the perforated pipe, and is exhausted through the fan. With this small volume of air the grain is not expected to cool rapidly. The fan is started in September or October, or whenever the air temperature is at least 10 F lower than the grain temperature. The fan can be operated continuously throughout the fall or winter or until the grain is cooled to the desired temperature. Studies of this method are being continued at government-owned bin sites to determine more specifically the minimum air flow requirements and the size of equipment needed to provide these air volumes and to determine if humidistatic and thermostatic controls of fans are practical.

Early in 1953 the Commodity Credit Corporation arranged to store government-owned surplus wheat in 75 inactive Liberty ships in the Hudson River reserve fleet above New York City and in 50 similar ships in the James River reserve fleet above Norfolk, Va. Prior to loading the ships, the Commodity Credit Corporation requested help in designing aeration equipment that could be used in cooling and equalizing temperatures of the grain stored in the ships.

Several problems were encountered in designing, installing, and operating the aeration units. There was no power source aboard the ships and no central power source readily available. Therefore, it was necessary to use portable generators which supplied 440-v, a-c, 3-phase current. It was necessary to use small fans and motors because of the limited power available.



Grain in elevators up to 150 ft high has been aerated by circulating from  $\frac{1}{30}$  to  $\frac{1}{50}$  cfm per bu through the grain with an electrical consumption of less than  $\frac{1}{10}$  kw-hr per bu

Fans were provided that delivered about 1,000 cfm at a suction pressure of 1-in water column and required an electrical input to the motor of about 325 w. These small units were able to circulate only about  $\frac{1}{30}$  to  $\frac{1}{40}$  cu ft of air per minute per bushel through the stored wheat which was over 20 ft deep in some of the ship holds. Six fans were provided for each ship, two for the largest (No. 2) hold and one each for the other four holds, giving a total of 450 fans and motors for the Hudson fleet and 300 for the James River fleet.

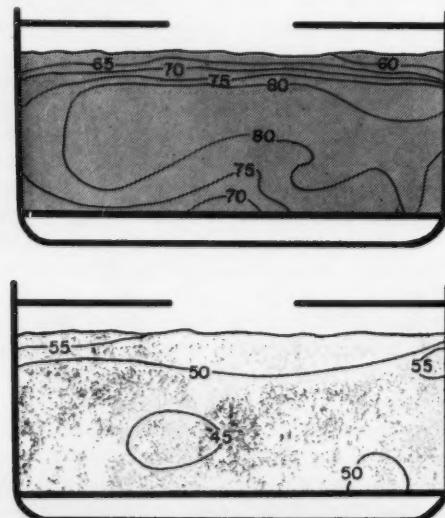
Two lines of 8-in-diam perforated tubes were laid lengthwise on the bottom deck of each hold to provide air ducts for circulating air through the wheat. The two lines were placed 8 ft each way from the center line of the hold because of the greater width (up to 56 ft) as compared with a depth of around 20 ft.

Wheat was stored in 5 holds of each ship, each hold ranging in capacity from 20,000 up to 75,000 bu. The amount of wheat stored in each ship averaged about 225,000 bu with a total of slightly over 17 million bushels at the Hudson River fleet and somewhat over 11 million bushels at the James River fleet.

Some of the wheat was loaded into the ships in late April but most of it was loaded during the summer months. Therefore, the temperature of much of the wheat at both fleets was above 75 F when stored with temperatures as high as 85 to 95 F in many of the ships. Even during the winter months much of the wheat in the central area of the hold cooled very slowly unless aerated. At the same time the outer layers of wheat cooled quickly with cold air above the wheat and cold water around it. Where the warm wheat was not cooled convection currents developed that caused moisture migration within the wheat bulk. This was illustrated in one ship loaded in August 1953 with wheat having an average moisture content of 12 percent. Wheat samples taken in January 1954 showed the following moistures:

Surface	13.8 percent
16 to 24 in below surface	12.5 percent
40 to 48 in below surface	11.9 percent

(Continued on page 672)



The effect of aeration on grain stored in ships. Top view shows temperature variations on November 5, 1953, in 70,000 bu of wheat stored in the hold of a ship with no fan operation. Wheat was loaded during the summer of 1953 when much of the wheat had a temperature of 80 F and above. Bottom view shows same wheat after 1,000 hr of fan operation on March 25, 1954

# Evapotranspiration Rates for Various Crops

Lloyd L. Harrold  
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**I**N MANY states of the humid section of the United States, engineers, agronomists, and soil scientists are engaged in the development of guides needed in the design of irrigation systems. Several states have already completed tentative guides, according to Beauchamp (1)\*. One of the basic design criteria for irrigation water application is evapotranspiration, commonly termed "consumptive use". Both the peak-use rates for periods of about 10 days as well as depth of soil from which most of this water is extracted needs to be evaluated for different crops. A thorough search of literature and current agricultural research in the humid areas revealed the fact that such data were scarce. Hydrologic data from the Coshocton, Ohio research station, although of short duration and for limited variety of crops, have been used widely in guiding the thinking in the development of the "consumptive-use factor" as a design criterion.

It is the purpose of this paper to present recently developed evapotranspiration data for different crops and seasons as an aid to those engaged in irrigation design as well as those engaged in setting up programs of irrigation research. Furthermore, these data may help orient the concepts concerning the use of such data for scheduling the operation of irrigation equipment, namely, the use of a soil-moisture bookkeeping method for estimating the time for and amount of water applications.

It is realized that the Coshocton data are limited in use because of (a) the short period of observation with and without irrigation, (b) fewness of crops evaluated and, (c)

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The author—LLOYD L. HARROLD—is project supervisor, Soil and Water Conservation Research Station (ARS), U.S. Department of Agriculture, Coshocton, Ohio.

**Acknowledgments:** For data and suggestions received, the author is indebted to F. R. Dreibelbis, soil scientist; R. E. Youker, agricultural aid; and Wm. W. Bentz, engineering aid at the Coshocton Station.

\*Numbers in parentheses refer to the appended references.

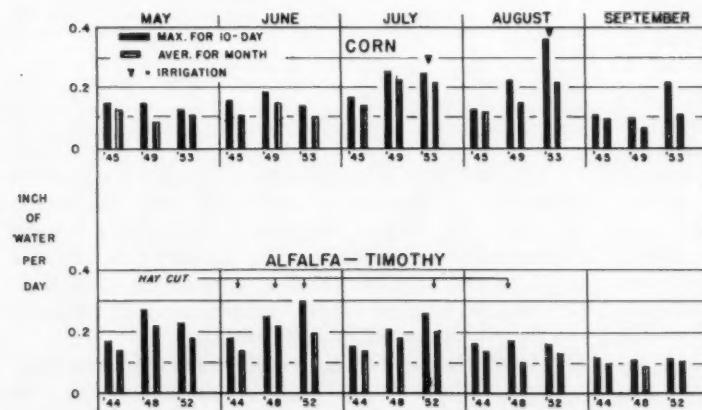


Fig. 1 Monthly average and maximum 10-day average daily evapotranspiration from cornland and alfalfa-timothy meadow gathered from lysimeter, Y102C, May through September, 1944 to 1953, at the Coshocton, Ohio, research station

Recently developed information on evapotranspiration rates for different crops and seasons, presented here as an aid to irrigation design, research and operation, might also prove to be a key to a simplified soil-moisture bookkeeping system for planning irrigation schedules

only two different soil types represented. Evapotranspiration data for unirrigated areas are of value in irrigation programs only for those periods of adequate soil moisture. Such data in dry periods are noticeably low. The fact that all the data have been used so widely emphasizes the general lack of research data in this field. This fact also makes one realize the importance of the Coshocton data which were gathered from their weighing, recording lysimeters. The features of these unique lysimeters have been described and a few years' data summarized by Harrold and Dreibelbis (2). Soil types are Muskingum silt loam (moderately rapid permeability) and Keene silt loam (slow permeability). Both are residual soils derived from shale. The row crop is field corn followed by winter wheat and two years of hay meadow.

In addition to the unique weighing lysimeters, at Coshocton, fiberglass-gypsum blocks have been used on sweet corn, potato, and strawberry plots to evaluate soil-moisture changes and evapotranspiration. The soil-moisture blocks were placed at different soil depths in order to obtain data needed to define the critical depth of moisture extraction by vegetation. Stackhouse and Youker (3) reported on the accuracy of the fiberglass-gypsum blocks for evaluating soil-moisture changes.

## Evapotranspiration rates

Evapotranspiration rates for three years of corn and three years of meadow varied noticeably from season to season (Fig. 1). That from cornland was greatest in July and August. Data from a second-year alfalfa-timothy meadow are given mainly to show the large difference between water use by corn and meadow in May and June. Differences later in the year were influenced by differences in available moisture. For unirrigated crops, evapotranspiration rates were sometimes low because of deficient soil-moisture supplies in the critical root zone. The August 1945 cornland consumptive-use average value of 0.12 in per day illustrates a case in dry weather. The August 1953 average rate of 0.22 in per day for the month on irrigated cornland more closely represents the value of consumptive-use when soil-moisture supplies are adequate.

August evapotranspiration rates for alfalfa-timothy for all 3 years, 1944, 1948, and 1952, were probably low because of limited soil-moisture supply. Monthly average rates of 0.14, 0.10, and 0.13 in per day in August might increase 50 to 100 percent under irrigation. Undoubtedly, crop yields also would increase with irrigation.

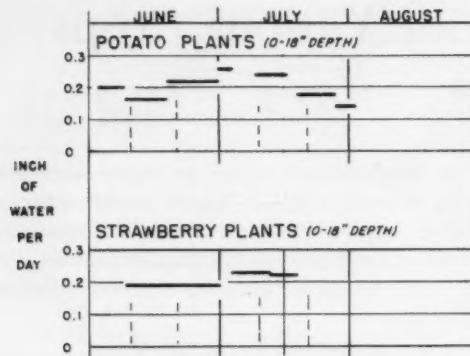


Fig. 2 Average daily evapotranspiration from irrigated potato and strawberry plots in 1954

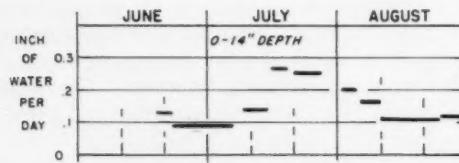


Fig. 3 Average daily evaporation from irrigated sweet-corn plots in 1954

Average daily values of consumptive use discussed above provide comparisons of seasonal water use by irrigated and non-irrigated corn and non-irrigated meadow crops. These values are inadequate for irrigation systems as they should be designed to meet a higher demand for water which prevails for short periods of ample soil moisture—specifically during high consumptive-use periods of no rainfall when repeat irrigations are required. Sometimes these periods may be of only 5 to 10 days duration. Peak consumptive-use values for 10-day periods from the lysimeters are shown in Fig. 1. Under conditions of natural rainfall, these cornland peak-use values were observed to exceed the monthly values usually by less than 0.04 in per day. The major exception to this was in August 1949 when the difference was 0.08 in per day. Under an irrigation program, the differences were noticeably greater—being 0.14 in per day greater in August 1953, and 0.11 in per day in September 1953.

These values may seem small, yet the least difference of 0.04 in per day amounts to 0.40 in in 10 days. The 0.14-in difference totals 1.40 in in a 10-day period. Such values are large enough to be given consideration in irrigation design.

On sweet corn, potato, and strawberry plots, where only periodic soil-moisture observations from blocks were available, it is not possible to derive such an exacting comparison as that obtained from the weighing lysimeters presented above. Results of field soil-moisture observations on these plots during 1954 are presented in Figs. 2 and 3. Moisture content for the indicated soil depth at the beginning of a period plus the rain and irrigation during the period minus the moisture content at the end of the period—all divided by the number of days in the period—gave the value of average daily evapotranspiration shown on these figures. Irrigation water was supplied to all three crops. Results showed that potato plants (Fig. 2) consumed moisture from a soil depth of 18 in at an average rate of 0.26 in per day for a 3-day period, and 0.24 in per day for 8 days in July. Average for

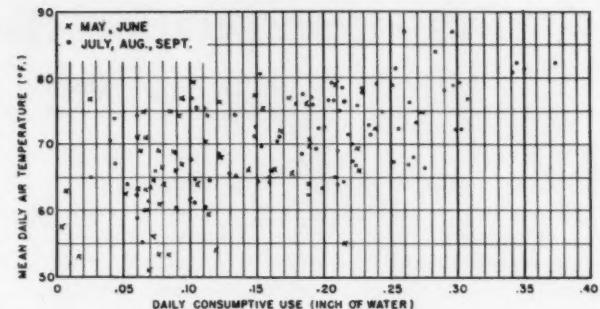


Fig. 4 Relation between air temperature and cornland consumptive use by days, lysimeter Y102C, May to September, 1953

July was about 0.21 in per day. Most of this moisture was extracted from the top 14 in of soil.

Strawberry plants (first-year) consumed moisture from an 18-in soil depth at a rate of 0.23 in per day for an 8-day period in July (Fig. 2). Most of this moisture was extracted from the top 10 in of soil.

Evapotranspiration rates from 14 in of soil by sweet corn (Fig. 3) built up to a maximum of 0.27 in per day for a 4-day period, and 0.25 in per day for 6 days in July. Average for the month was probably less than 0.19 in per day.

More years of data with more frequent observations will make it possible to evaluate consumptive-use figures with a higher degree of accuracy for a wider range of climatic experience.

#### Air Temperature vs. Evapotranspiration Relationship

There is a noticeable difference in average monthly evapotranspiration rates for the three different years, 1945, 1949, and 1953 (Fig. 1). For example, in June the 1945 and 1953 average monthly values were about the same, whereas that for 1949 was much greater. Air-temperature data (mean of daily maximum and minimum values) for these periods as given in Table 1 show that June in 1949 was warmer than in 1945 or 1953. In July the larger values of evapotranspiration correspond with higher air temperatures. In May and August there are some inconsistencies between the three years.

TABLE 1. MONTHLY MEAN AIR TEMPERATURE IN DEGREES F (30 IN) AND EVAPOTRANSPIRATION (ET-CA) IN INCHES FOR CORN, LYSIMETER Y102C, 1945, 1949, 1953

Month	Temp.	ET-CA	1945		1949		1953	
			Temp.	ET-CA	Temp.	ET-CA	Temp.	ET-CA
May	54.6	4.19	62.0	2.90	63.5	3.28		
June	68.0	3.39	73.3	4.41	71.0	3.26		
July	71.8	4.28	77.2	7.21	73.5	6.79		
August	73.8	3.70	70.2	4.84	73.5	6.75		
September	67.1	2.96	61.4	2.23	65.9	3.45		

It is likely that lack of moisture in August is one of the reasons for this variation. It is also to be noted that in 1945 and 1949, the August temperatures are greater but the evapotranspiration is lower. This difference is also due mostly to moisture deficiencies in August. In 1953, however, the soil-moisture supply was maintained by irrigation and the evapotranspiration remained high.

The relationship between monthly values of air temperature and of evapotranspiration (consumptive use) may seem reasonable at times. A corresponding study of daily values for the irrigation year (Fig. 4) shows a wide scattering of points. The relationship appears to be too erratic for prac-

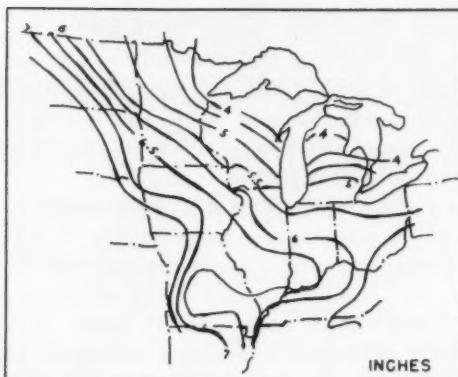


Fig. 5 Mean evaporation from lakes during the month of July (after Meyer)

tical use in the field of agricultural hydrology. One might conclude that air-temperature values were not the answer in the search for a single, simple key to the problem of evaluating daily consumptive use for crops. Relative humidity, wind movement, and solar radiation along with air temperature combine to cause evapotranspiration.

Solar radiation values are available at only a few isolated places in this country.

#### Pan Evaporation vs. Evapotranspiration Comparison

As variations in climate from place to place affect evapotranspiration, it becomes necessary to adjust the Coshocton data for application elsewhere. Climatic factors of solar radiation, wind movement, and atmospheric moisture, are generally considered as exerting the most influence on evapotranspiration. These data are not generally available. Even if readily accessible, they are most difficult to correlate with evapotranspiration. Some device such as a pan for measuring water-surface evaporation, data for which are most generally available and which would evaluate the combined effect of climate on evapotranspiration, is being considered as a tool for adjusting the Coshocton data for application elsewhere. Water-surface evaporation has been calculated and maps of mean monthly evaporation prepared by Adolph Meyer (4). If proven practical, it is a ready tool for use almost anywhere within reason. An evaporation map for July of the North Central states appears on Fig. 5.

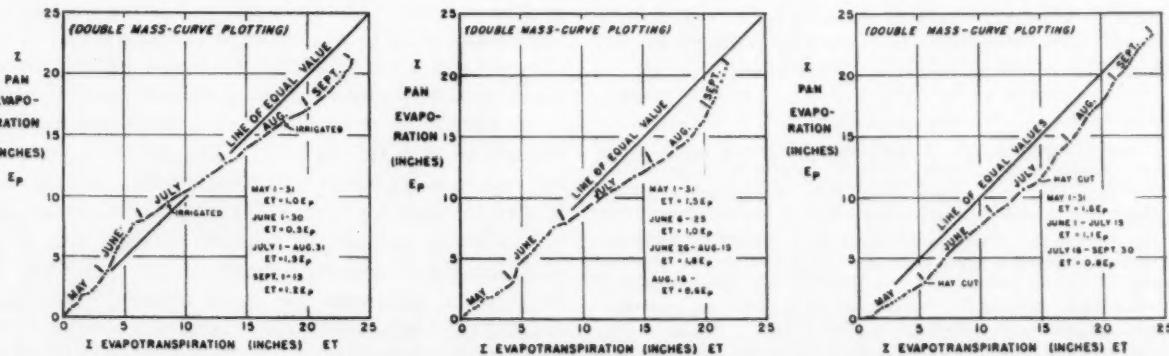
If the irrigation farmer had evaporation pan data on site and had factors for deriving therefrom day-by-day

moisture-use values for his crop throughout the season, he might be able to keep a set of books on the available moisture—rain and irrigation added on the plus side and consumptive use on the minus side of the ledger. The following results show that an evaporation pan-consumptive-use factor may be possible.

Evapotranspiration for cornland as evaluated by the Coshocton lysimeter Y102C having a 12 percent east slope is compared with the BPI-type evaporation pan data for 1953 by the double-mass curvet type of plotting (Fig. 6). BPI-pan (6 ft sunken) evaporation data, according to Rohwer (5), correspond closely to that from free water-surfaces. The latter have been mapped by Meyer (4). Data on Fig. 6 show some promise of a relationship between evapotranspiration,  $ET$ , and pan evaporation  $E_p$ : ( $ET = 1.5 E_p$ ) during July and August, a period in which soil-moisture supplies were maintained adequately by irrigation. The May and June relationship appears to be influenced by soil surface moisture. During May when the soil surface was moist,  $ET = 1.0 E_p$ . During June when the soil surface was drier,  $ET = 0.5 E_p$ . After July 1, the evapotranspiration was apparently unaffected by wet or dry soil surfaces. In other words, consumptive use during July and August was mostly transpiration, evaporation being minor. In May and June evaporation was relatively more prominent, since transpiration was low.

On lysimeter Y103A, which lies on a 6 percent south slope, the May and June relationship (Fig. 7) is somewhat similar to that of Y102C (Fig. 6) which lies on a 12 percent east slope. The slope of the June lines, in both cases, is greater than that for May. The July and August relationship for Y103A is also similar to that for Y102C as long as the moisture lasted. By mid-August, the Y103A curve broke up noticeably as a result of reduced evapotranspiration rates. Rainfall from August 10 to September 3 amounted to only 0.07 in. Soil-moisture supplies in the 24-in depth failed to

The double-mass curve as used herein, and illustrated in Figs. 6, 7 and 8, is simply the plotting of the value of accumulated evapotranspiration against the value of accumulated pan evaporation for the corresponding date. Accumulations started May 1, and were continuous through September 30. Six values were plotted for each month. The slope of a double-mass curve plotting is significant. If the slope is parallel to the line of equal values, then the rates of pan evaporation and crop evapotranspiration are equal. If the slope of the curve is steeper, the rate of pan evaporation is greater than that of evapotranspiration. The months are listed to provide an indication of the stage of crop growth. The approximate dates of irrigation and crop harvest are shown.



Figs. 6, 7, and 8 Double mass-curve plotting shows relationship between evapotranspiration and pan (6 ft sunken) evaporation. Fig. 6 (Left) Irrigated corn on land having a 12 percent east slope, Y102, 1953 • Fig. 7 (Center) Cornland on a 6 percent south slope, Y103, 1953 • Fig. 8 (Right) Alfalfa-timothy, Y102, 1952

meet the high demand rate by corn plants from mid-August on.

Pan evaporation vs. evapotranspiration relationship for alfalfa-timothy meadow (Fig. 8) is used to show the greater use rate for meadow in May and June as compared to that for corn (Fig. 6). The steepening of the relationship line after hay cutting reflects the reduced evapotranspiration rates that prevail for about 10 days after cutting and removal. Under an irrigation program, it is possible that the relationship line from mid-August on might not break so noticeably from the preceding slope.

Pruitt and Jensen (6) compared measured consumptive use with pan evaporation at Prosser, Wash., for the period 1949 to 1953 and found a good relationship after the crop had become established.

#### Soil Moisture extraction Patterns

Moisture-extraction patterns on field corn, sweet corn, potatoes, and strawberries as determined from fiberglass-gypsum blocks indicate that the maximum depth of soil to be considered for irrigation on the Coshocton soils should be somewhat as follows: field corn, 24 in.; sweet corn, 14 in.; potatoes, 14 in. and strawberries, 14 in. Actually strawberries used very little water from the soil depth below 10 in.

#### Discussion

Evapotranspiration rates for different crops vary notably throughout the growing season. Stage of development of vegetative cover of ground surface, availability of moisture for evapotranspiration, and fluctuations in climate appear to be major factors influencing evapotranspiration rates. Data from lysimeters and fiberglass-gypsum electrical-resistance blocks were used to develop evapotranspiration rates. These data showed that consumptive-use rates for alfalfa-timothy reached high values much earlier in the growing season than those for corn. Average peak-use rates for 10-day periods for corn exceeded the average monthly values by as much as 0.04 in per day under normal rainfall conditions. With soil-moisture supplies maintained at high levels as under irrigation, the peak-use rates differed more noticeably from the average monthly values—as much as 0.14 in per day. In the engineering design of irrigation systems, the average peak-use rates for periods of about 10 days are commonly used rather than the average monthly values.

Pan evaporation data may be useful in developing soil-moisture "bookkeeping" procedures for farm use in scheduling the time and amount of irrigation. Results of evapotranspiration and pan evaporation studies at Coshocton show that such a method might be possible if the crop-variation and the available moisture factors can be evaluated and can be correlated with water-surface evaporation.

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- 3 Stackhouse, John M. and Youker, R. E. Evaluation of the accuracy of fiberglass-gypsum blocks for measuring soil moisture changes. *Agron. Journal*, Vo. 46, September 1954.
- 4 Meyer, Adolph F. Evaporation from lakes and reservoirs. Minnesota Resources Commission, June 1942.
- 5 Rohwer, Carl. Evaporation from different types of pans. *ASCE Transactions* No. 99, 1934, pp. 673-703.
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#### Aeration of Stored Grain

(Continued from page 668)

The wheat temperature near the surface at that time was 37 F while that in the center of the bulk was 77 F. This wheat was cooled thus eliminating convection currents and preventing moisture migration.

It was obvious that the small fans delivering only  $\frac{1}{30}$  to  $\frac{1}{40}$  cfm per bu would have to be operated for a long period during cool or cold weather in order to cool the grain down near the outside air temperature. Most of the fans were operated from 800 to 1,000 hr and by April 1, 1954, the temperature of the wheat in most ships was considered to be low enough for safe summer storage. By that time much of the wheat at the Hudson River fleet had temperatures below 45 F and wheat at the James River fleet had temperatures below 50 F. About  $\frac{1}{10}$  kw-hr of electricity per 100 bu of wheat was used in aerating the stored wheat during the fall and winter of 1953 and 1954.

Research is being initiated by the handling and facilities research section, Agricultural Marketing Service, USDA to determine if mechanical aeration can be effectively applied to commercial storages, both upright and flat types, to eliminate the need for turning grain. Commercial grain handlers follow the practice of periodic turning or "running" of grain from one bin to another where grain is stored for more than a few weeks. This is done to equalize grain temperatures and to obtain some cooling if weather conditions are favorable. From results of mechanical aeration tests in circular bins, large flat storages, and in ship storages it is believed that similar aeration practices can be adapted to commercial storages and thus eliminate the necessity of turning much of the grain.

A number of commercial operators are interested in this practice if it will minimize turning of stored grain. A number of systems will be tested in several states. For example, in Iowa tests will be conducted in silo-type bins holding 30,000 bu of grain. An estimated air flow rate of 0.1 cfm per bu will be circulated through a grain depth of 60 ft with a  $7\frac{1}{2}$  to 10-hp electric motor. The estimated pressure drop through the grain under the conditions stated above is about 10 in water gage. Another example is an aeration test in Ohio where an attempt will be made to aerate 60,000 bu of grain in a tank 150 ft in height. It is proposed to use an air flow rate of  $\frac{1}{30}$  to  $\frac{1}{40}$  cfm per bu in doing this job. It is estimated that a  $7\frac{1}{2}$ -hp electric motor and a high-pressure fan or blower capable of working against pressures up to 12 in. water gage, will be required to supply this air flow rate through a wheat depth of 150 ft. Results from these and other similar studies will show whether aeration can be used to advantage in conditioning grain in commercial storages and to eliminate the need for turning grain.

Entomologists are also interested in the possibility of using similar equipment for circulating and recirculating fumigants through stored grain. They have made preliminary tests which indicated that better results can be obtained by using blowers and ducts to apply the fumigants than by using ordinary methods.

## INSTRUMENT NEWS

KARL NORRIS, Editor

Sponsored by the ASAE Committee on Instrumentation and Controls. Contributions on agricultural applications of instruments and controls and related problems are invited, and should be submitted direct to K. H. Norris, Agricultural Research Center, Beltsville, Md.

### Rapid Method for Determining Mean Values and Areas Graphically

S. I. Askovitz

THE observed data in many fields of scientific investigation are recorded on continuous graph paper, charted either manually or by various motor-driven devices. It is frequently necessary to determine the mean value of the recorded quantity from such a chart, or to estimate areas bounded by such graphs. A simple method (1)\* was devised for accomplishing either of these ends. This method requires only a pencil and ruler (or straightedge) and can be completed by means of a single broken line without lifting the pencil from the paper. The technique was originally developed for the analysis of lengthy temperature records, and has since been applied to electroradiograms, ballistocardiograms, electrophoresis patterns, tonograms, and a variety of data recorded at timed intervals. One of the chief advantages of this method is that mean values can be obtained directly on the original graph, without transcribing numerical values or performing any arithmetical calculations.

*Method.* As an example, take eight values recorded on ordinary rectangular graph paper at points *A*, *B*, *C* . . . *H* (Fig. 1). The technique will be seen to be the same no matter how small or how large the number of points. It is assumed that the horizontal spacing or "timing" between the points is uniform.

Paper reprinted with permission from *Science*, February 11, 1955, vol. 121, no. 3137, pp. 212-213.

The author—S. I. Askovitz—is a medical doctor, Ophthalmology Research Laboratory, Albert Einstein Medical Center, Northern Division, Philadelphia.

\*Numbers in parentheses refer to the appended references.

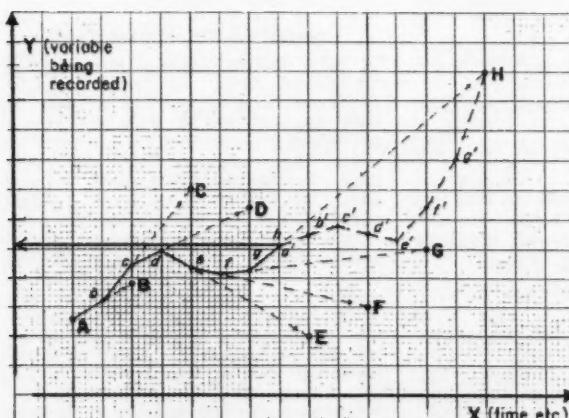


Fig. 1 Graphical determination of mean values

Place a ruler so that it passes through points *A* and *B*. Start with the pencil at *A* and draw *Ab*, stopping on the vertical line midway between *A* and *B*. Next, with the pencil held at *b*, turn the ruler so that it passes through *b* and *C*. Draw *bc* along *bC*, stopping on the vertical line through *B*. Next, with the pencil held at *c*, turn the ruler so that it joins *c* and *D*, and draw *cd* as shown. Continue in this manner, each time directing the straightedge toward the next in the series of points and advancing the pencil to the right by half the space between the vertical lines through the original points, until arriving at the final point *b*. The height of *b* above the horizontal axis, measured according to the vertical scale used for the graph, provides the desired mean value.

Although the simplicity of this method renders it relatively free from error, a brief check is readily available and should be performed. Start at *H*, and along *HG* draw *Hg'* (Fig. 1), then *g'f*, and so on until *a'* is reached. The point *a'* will coincide with *b* if no errors have been made.

*Proof.* By employing a few properties of centroids (centers of gravity), a nonalgebraic proof can be provided. Assume that a mass of 1 unit is placed at each of the points *A*, *B*, *C* . . . *H*. Then the centroid of all of these points will have a height above the horizontal axis equal to the arithmetic mean value of the height of the individual points. In arriving at the centroid geometrically, points *A* and *B* with mass 1 unit each may be replaced by a mass of 2 units placed at *b*. This may be represented by the symbol *b*<sub>2</sub>. The centroid of *b*<sub>2</sub> and *C*<sub>1</sub> is situated at *c*, along the segment *bC*, dividing the length *bC* in proportion to the masses, and nearer to the "heavier" point. Similarly *c*<sub>3</sub> and *D*<sub>1</sub> may be replaced by *d*<sub>4</sub>, and so on until *b*<sub>8</sub> represents the combined mass at the centroid.

*Comments.* The procedure described may be applied to a record consisting of any number of discrete points. In the case of a continuous graph, it is necessary to mark off, along the graph, points equally spaced horizontally, and to apply the method to these selected points. The accuracy of the final result will in general increase as the subdivisions are made finer.

In order to estimate areas under curved graphs (that is, the area between a portion of the curve, two vertical lines and the corresponding portion of the horizontal axis), it is necessary merely to multiply mean value, as derived above, by the length of the horizontal extent.

A review of the relevant literature on graphical methods revealed only a single reference (2) to a method at all comparable. However, the present method proved to be considerably easier and more rapid to apply.

#### References

1 From the Ophthalmology Research Laboratory (I. H. Leopold, director), Albert Einstein Medical Center, Northern Division. This work was made possible by a grant from the Weinstock Fund.

2 Lipka, J. Graphical and Mathematical Computation, Pt. II, Experimental Data (Wiley, New York, 1921), pp. 237-242.

# NEWS SECTION

## G. E. P. Smith Elected Honorary Member

INFLUENCED by loyal and active service to the Society, retirement from active service of more than fifty-five years at the University of Arizona, and contributions, particularly in the field of engineering as applied to irrigation, the Council of ASAE recently has elected Dr. G. E. P. Smith to the grade of Honorary Member in the Society.

George Edson Philip Smith was born December 29, 1873, in Lyndonville, Vt. He received a C.E. degree from the University of Vermont in 1899 and in 1929 the same institution awarded him the honorary degree of doctor of engineering. Dr. Smith was professor of civil engineering from 1900 to 1906; professor of irrigation engineering since 1906, and head of the irrigation and agricultural engineering department, University of Arizona, until 1944.

Dr. Smith introduced the caisson well, wrote the water code for Arizona, and assisted in the development of pump irrigation in the Southwest. He is author of more than 100 publications, many of which are on irrigation and groundwater. He was first to advocate the widespread use of well water for irrigation, to analyze the physiography of Arizona valleys, and to warn of the ultimate disaster which must result from overpumping areas which have little annual recharge. He was first to advocate the use of tamarisk wood and creosoting this wood for fence posts in Arizona.

His retirement from active duty from the University of Arizona became effective July 1, 1955. He is a past-chairman of the Pacific Coast Section of ASAE.

## ASME Diamond Jubilee Meeting

THE American Society of Mechanical Engineers' diamond jubilee annual meeting will be held in Chicago at the Congress, Conrad Hilton and Sheraton-Blackstone hotels from November 13 to 18.

More than 300 technical papers at 110 sessions are planned for the six-day event.

The American Rocket Society, an affiliate of ASME, is celebrating its 25th anniversary this year and is holding sessions within the ASME meeting.

At a special honors luncheon, five major joint engineering awards will be conferred. These are: The Hoover medal to C. F. Kettering; John Fritz medal to Philip Sporn; Elmer A. Sperry award to W. F. Gibbs; Henry L. Gantt memorial medal to Walker L. Cisler, and the Daniel Guggenheim medal, the recipient to be announced.

Sidelighting the 75th anniversary celebration will be the "Exposition of Power and Mechanical Engineering" at the Chicago Coliseum from November 14 to 18. Under the auspices of ASME, the exposition will feature displays showing the newest engineering developments.



G. E. P. SMITH

## Fluid Power Program

THE National Fluid Power Association will hold its fall meeting at the Edgewater Beach Hotel, Chicago, November 2-4. The first day will be devoted primarily to marketing subjects, the second day to public, industrial and government relations and to education and other subjects of general interest, and the third day to technical matters of which trends and progress toward standardization of terminology, rating factors and limited dimensional standards will predominate. Details concerning the program and other arrangements for the meeting may be obtained from the Association's executive secretary, Barrett Rogers, 1618 Orrington Ave., Evanston, Ill.

## Hydraulics Conference

THE 11th annual National Conference on Industrial Hydraulics will be held October 27 and 28 at the LaSalle Hotel, Chicago.

The two-day meeting will consist of sessions for the presentation of papers and panel discussions on up-to-date information on both fundamental and applied phases of industrial hydraulics. Sessions will be devoted to such subjects as hydraulic fluids, pumps, pneumatics, mobile equipment, presses, automotive, analog computers, machine tools, aircraft controls, and components and accessories.

## ASAE Meetings Calendar

October 13 — CONNECTICUT VALLEY SECTION, Publick House, Sturbridge, Mass.  
October 13-14 — GEORGIA SECTION, Georgia Coastal Plain Experiment Station, Tifton, Georgia.  
October 14 and 15 — FLORIDA SECTION, Gainesville, Fla.  
October 17 — CHICAGO SECTION, Caterpillar Tractor Co., Joliet, Ill.  
October 19-21 — PACIFIC NORTHWEST SECTION, Heathman Hotel, Portland, Ore.  
October 20 — MINNESOTA SECTION, Minnesota Mining and Mfg. Co., St. Paul, Minn.  
October 20-21 — PENNSYLVANIA SECTION, Holiday Motor Hotel, Gettysburg Interchange, Harrisburg, Pa.  
October 21 and 22 — ALABAMA SECTION, Auburn, Ala.  
October 22 — MICHIGAN SECTION, East Lansing, Mich.  
November 4 — QUAD CITY SECTION, The Tower, Moline, Ill.  
November 4 and 5 — VIRGINIA SECTION, Hotel Roanoke, Roanoke, Va.  
December 12 to 14 — WINTER MEETING, Edgewater Beach Hotel, Chicago  
December 29 and 30 — PACIFIC COAST SECTION, Tucson, Ariz.  
February 6-8 — SOUTHEAST SECTION, Atlanta, Georgia  
June 17-20 — 49TH ANNUAL MEETING, Hotel Roanoke, Roanoke, Va.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

## Sprinkler Irrigation Association Meets

THE Sprinkler Irrigation Association will meet in convention at the Broadmoor Hotel, Colorado Springs, Colo., on October 23 to 27. Program and details of the meeting may be obtained by writing the Association's headquarters, 1028 Connecticut Ave., N.W., Washington, D.C.

## Program to Feature Greases For Farm Machines

THE annual meeting program of the National Lubricating Grease Institute at Chicago, October 31 to November 2, will include a panel discussion on lubricating greases for modern farm machinery. Featured on the panel are Dale O. Hull, extension agricultural engineer, Iowa State College, and N. A. Sauter, lubrication engineer, Deere & Company.

## Farm Safety Program

THE 43rd National Safety Congress and Exposition will be held October 17 to 21 at the Conrad Hilton, Blackstone, Congress, LaSalle and Morrison Hotels, Chicago.

Farm safety programs will be conducted three days at the Morrison Hotel. A. J. Schwantes, head of the agricultural engineering department, University of Minnesota, will preside at the Tuesday morning, October 18, meeting which will be a joint session with rural youth. The afternoon program will be on the subject "Farm Electricity and Insecticides," and V. S. Peterson, E. I. du Pont de Nemours & Co., will preside. L. L. Koontz, Appalachian Electric Power Co., will speak on safety with electricity on the farm.

The Wednesday afternoon, October 19, program will deal with farm fire prevention with Russell Heston, assistant secretary, National Association of Mutual Insurance Co., presiding. Martin Ronning, chief engineer, power machinery division, Minneapolis-Moline Co., will preside at the Thursday morning, October 20, meeting. Irving A. Duffy, vice-president, Tractor and Implement Division, Ford Motor Co., Birmingham, Mich., will speak on industry's stake in farm safety.

## Presents New Movie Film

A NEW motion picture in color, entitled "County Agent," has been released by The Texas Company and will be shown at farm meetings to be held by Texaco throughout the country.

The film covers activities of county agents in four widely separated farming areas. Joe Powell, county agent of Edgecombe County, N. C., portrays the work of the county agent in tobacco country. Walter Sullivan, county agent of Holmes County, Miss., dramatizes the duties of the county agent in the deep South. Problems of the midwestern farmer are presented by Joe Carroll, county agent of Jasper County, Ind. Marion Bunnell and his staff of eleven agents run through their activities in Yakima County, Wash.

Copies of the film for farmer meetings are available through local Texaco zone manager, consignee or distributor.

## 1955 Winter Meeting Program Preview

THE 1955 winter meeting of the American Society of Agricultural Engineers will be held December 12, 13, and 14 at the Edgewater Beach Hotel, Chicago. The executive committees of the Society's four technical divisions—Power and Machinery, Soil and Water, Farm Structures, and Rural Electric—presently are in the process of completing arrangements with prospective speakers for what promises to be a most interesting and informative program.

Advance registration cards and hotel reservation forms will be received by ASAE members shortly. Non-members interested in attending the meeting should communicate with the central office of the Society at St. Joseph, Mich., for information on accommodations and the program of the meeting sessions.

Highlights of the program in the present state of preparation are as follows:

### Power and Machinery Program

The presiding chairman of the first session of the power and machinery program on Monday forenoon, December 12, will be the chairman of the Power and Machinery Division, Byron T. Virtue (vice-president, engineering, Bearings Division, The Torrington Co.). The program will open with a paper on power steering systems by C. W. Lincoln, Saginaw Steering Corp., division of General Motors, followed by prepared discussion by a representative from the farm tractor industry. The second paper will be on controlling two-way leveling of hillside combines by S. D. Pool, chief engineer, product engineering, International Harvester Co. There will be a prepared discussion by a representative of Deere & Co.

Power and Machinery men will have a choice of meetings on Monday afternoon. A joint meeting with the Soil and Water Division will be devoted to irrigation pumps and power units, (see outline of program under Soil and Water Program). For men of interests not related to the subject covered in the joint meeting, a concurrent program will be held by the Power and Machinery Division. This program will include the following papers: "Recent Agricultural Chain Developments" by J. H. Thuerman and E. A. Paul, Chain Belt Co.; "An Evaluation of Reinforced Plastics for Agricultural Equipment" by J. K. Burkley, section head, reinforced plastics division, Goodyear Aircraft Corp.; and "Application of Granular Material for Control of European Corn Borer" by W. G. Lovely and H. A. Myers, respectively, of USDA and Iowa State College. L. G. Kopp, (chief engineer, South Bend Plant 1, The Oliver Corp.) vice-chairman, Power and Machinery Division will preside.

Presiding at the morning session, Tuesday, December 13, will be the junior past-chairman of the Power and Machinery Division, Roy Bainer, (chairman, agricultural engineering department, University of California). "Statistical Techniques in Evaluating Harvester Elements" by Wm. T. Mills, North Carolina State College, will be the opening paper. "Radioactive Tracer Techniques of Wear Determination" by E. N. Scarborough, former product analyst, Thompson Products, Inc., and "Principles of Agricultural V-Belt Development" by D. L. Waugh, director of V-belt research, The Dayton Rubber Co., will complete the morning program.

Chairman Byron T. Virtue will preside at the forenoon session on Wednesday, December 14, which will open with a paper

on "Wheel-Controlled Disk Harrow Studies", by A. W. Clyde, Pennsylvania State University. It will be followed by paper entitled "A Study of Disk Blade Testing Methods", by V. G. Fuhrwerk, New Idea Co. Martin Erickson, Tractor and Implement Division, Ford Motor Co., will present a paper on "Stress Coat and Strain Gages in Analysis of Tractor Components Under Field Operating Conditions". The session will be concluded with a progress report of the Committee on Soil Compaction by Roy Bainer, chairman.

Presiding at the Wednesday afternoon session will be L. G. Kopp, vice-chairman of the Power and Machinery Division (chief engineer, South Bend Plant No. 1, The Oliver Corp.). The first paper will be "Development of a New Type Corn Picker", by C. B. Richey, research engineer, Tractor and Implement Division, Ford Motor Co. The final paper of the program will be "Analysis of Dynamic Stability of Wheel-Type Tractors" by Hans W. Sack, engineering research, John Deere Waterloo Tractor Works.

### Soil and Water Program

The Soil and Water Division has planned a program featuring a half-day session for each of its four groups and also a joint meeting with the Power and Machinery Division.

Howard Matson, chairman, Hydrology Group, (head, engineering and watershed planning unit, U.S. Soil Conservation Service, Fort Worth, Tex.) is to preside at the opening session, Monday forenoon, December 12. A panel discussion on the subject "How Evaporation and Transpiration Enter into Various Phases of Agricultural Engineering" will begin the program at 9:30 a.m. Panel members will include John R. Davis or Paul E. Schleusener, Harry Blaney and James E. Garton. A paper by W. O. Ree, project supervisor (SWCRB, ARS) USDA, Stillwater, Okla., entitled "Retardance Coefficients for Row Crops in Diversions" and a paper by Franklin R. Crow, Oklahoma A. & M. College, entitled "Runoff Studies in the Reddish Prairie Grasslands of Oklahoma", will complete the forenoon program.

Monday afternoon, a joint meeting will be held with the Power and Machinery Division. John F. Schrunk, chief engineer, Irrigation Equipment Co., Denver, will preside. L. H. Kessler, chief hydraulic engineer, Kansas City Works, Fairbanks, Morse & Co., will open the meeting with a paper on "Centrifugal, Propeller, and Turbine Pumps—Their Place in Modern Irrigation". A panel discussion on "Internal-Combustion Power Units for Irrigation Pumping" will follow. Mr. Schrunk will serve as moderator. Representatives of engine companies will serve as panel members (speakers to be selected). Following the panel discussion a talk is planned on the use of tractor pulley or power take-off for irrigation by a representative from a tractor manufacturer with prepared discussion by a member of the Nebraska tractor test group. The afternoon program will be concluded with a discussion group on "Code of Ethics for Sprinkler Irrigation" led by Allan W. McCulloch, irrigation engineer, W. R. Ames Co., San Francisco, Calif.

Wayne D. Criddle, chairman, irrigation group, Soil and Water Division, (professor of irrigation and drainage, Utah State Agricultural College, Logan) will preside at the Tuesday forenoon session. Details of the program were not received in time for publication.

Presiding on the Wednesday forenoon program will be James J. Coyle, chairman of the ASAE Subcommittee on Terracing, (agricultural engineer, U.S. Soil Conservation Service). A paper entitled "The Requirements of Tillage Equipment in Effective Wind Erosion Control", by Neil P. Woodruff, agricultural engineer, (SWCRB, ARS) USDA, will open the program. Other papers on the morning program will include "Water-Disposal Systems in Orchards", by J. L. Aull, engineer, U.S. Soil Conservation Service; "The Influence of Terraces on Run-off Water", by Maurice B. Cox, agricultural engineer, (SWCRB, ARS) USDA; "A Time Study on Parallel Terraces", by D. D. Smith, agricultural engineer, (SWCRB, ARS) USDA, and "Improved Techniques in Terrace System Layout and Construction", by L. Donal Meyer and R. P. Beasley, respectively, agricultural engineer, (SWCRB, ARS), USDA, and agricultural engineer, University of Missouri, Columbia.

K. H. Beauchamp, chairman of Drainage Group, (U.S. Soil Conservation Service, Milwaukee, Wis.) will preside at the Wednesday afternoon program. A paper, entitled "Soil Moisture and Soil Temperature in Relation to Tile Drainage", by Melville L. Palmer, extension agricultural engineer, Ohio State University, Columbus, will open the afternoon session. It will be followed by a paper entitled "Results and Progress of Land Smoothing to Improve Surface Drainage", by J. W. Borden, Eversman Mfg. Co. After a short intermission, H. N. Luecke, drainage engineer, J. E. Greiner Co., will present a paper on "Agricultural Drainage on the Ohio Turnpike". The Wednesday afternoon program will be concluded with a paper on "Performance and Operating Cost of Tile and Operating Machines", by R. K. Frevert, G. O. Schwab and L. L. DeVries, Iowa State College.

A meeting of the steering committee of the Soil and Water Division is planned for Monday evening. The Committee on Agricultural Water Storage and Use will meet Tuesday morning at 8:00 a.m. ASAE committees on infiltration and on surface drainage will meet concurrently Tuesday evening. The Committee on Evapotranspiration will meet at 11:45 a.m. Tuesday. The Committee on Design and Construction of Tile Drains and the Committee on Ditchbank Erosion Control meet on Wednesday morning.

### Farm Structures Program

Theme of the opening session of the farm structures program is "Around the Modern Farmstead." C. F. Kelly, chairman, Farm Structures Division, (agricultural engineering department, University of California) will preside. A paper, entitled "Linear Programming, a Technique for Planning" by Myron Tribus and Ron Manly, engineering department, University of California, will open the morning session. It will be followed by a paper by Thayer Cleaver, USDA, on the subject of "West vs. East in the Milking Barn". Discussion on the paper will be led by W. H. M. Morris, Purdue University. "Fire Problems on the Modern Farmstead" by Henry Giese, Iowa State College, will be the next number on the program. To conclude the forenoon session, M. O'Brien, University of California, will present a paper on "The Farm Shop as a Production Building." Benson J. Lamp, Ohio State University, will discuss Mr. O'Brien's paper.

M. L. Esmay, vice-chairman, Steering Committee, Farm Structures Division, (agricultural engineering department, Michigan State University) will preside at the Monday afternoon session. The session theme is



Aerial view of the outdoor exhibit area of the Centennial of Farm Mechanization held August 15 to 20 commemorating the centennial anniversary of Michigan State University. Over 100 acres of exhibits were on display (story appeared in September issue of AGRICULTURAL ENGINEERING)

"Silo Research". (A. T. Hendrix, Agricultural Research Service, USDA, will open the session with a paper entitled "Status of Research in Horizontal Silos". It will be discussed by C. K. Otis, University of Minnesota. A paper on "Pressures in Bunker Silos", by D. B. Brooker, University of Missouri, and discussion by J. R. McCalmon, agricultural engineering research branch, USDA, Beltsville, Md., will follow. A paper, "Temperatures and Chemical Changes in Silos", by G. Zoerb, South Dakota State College, and discussion by C. Rogers, agronomy department, Ohio State University, will conclude the afternoon program. From 4:00 to 6:00 p.m. a farm structures smoker is planned, with O. R. Williams (Indiana Farm Bureau Cooperative Association, Indianapolis) presiding as chairman of the Smoker Committee.

A joint meeting with the Rural Electric Division is planned for Tuesday forenoon, December 13. This meeting is arranged and sponsored by the Committee on Agricultural Processing. (See program details in section on Rural Electric Program)

Tuesday afternoon is devoted to a general meeting sponsored by the Education and Research Division.

The Wednesday forenoon program theme will be "Manufactured Buildings". Frank J. Reynolds, vice-chairman, Farm Structures Division, (U. S. Steel Co.) will preside. Deane G. Carter, University of Illinois, will open the session with a paper on "Round-up of Manufactured Buildings". Other papers on the morning program will include, "Chicks and Prefabricated Laying Houses" by E. F. Dickey, vice-president, Honeggers and Co., discussion by Milton R. Dunk, editor, *Poultry Tribune*; "Farmer Concrete Tilt-up Construction" by R. C. Geisecke and Price Hopgood, A. & M. College of Texas, discussion by W. G. Kaiser; "Unistrut-Farm Erector Set" by George Butler, president, Unistrut Corp., Chicago, discussion by C. F. Kelly, University of California, and "Farmer Erection of Prefabs" by E. L. Logrbrinck, vice-president, Wonder Building Corp.

Theme of the Wednesday afternoon session is "Technical Developments Relating to Structures". C. F. Kelly, chairman Farm Structures Division, will preside. "Red Iron Oxide Barn Paints" by D. F. Lough-



Working models and colorful and historical slides drew much attention to the ASAE booth at the MSU centennial celebration. The 4 by 10-ft oil painting in the background depicts the role of agricultural engineering as a professional career. Attendants (left to right) Ralph A. Palmer, acting secretary, ASAE; Keith L. Pfundstein, and Merrill J. Anderson of Ethyl Corp.

nan, Forest Products Laboratory, USDA, will open the short afternoon session. It will be followed by a paper by L. W. Bonnickson, Oregon State College, on the subject of "Prefab Panels for Pole Frame Structures." To conclude the program will be a paper on "Heating of Air with Solar Energy", by F. H. Buelow, Michigan State University.

#### Rural Electric Program

The final draft of the program of the Rural Electric Division was not received in time for publication, but a list of the subjects to be covered during the meeting was sent in by H. S. Pringle, chairman of the Rural Electric Division (extension service, USDA).

"Farm Wiring" will be the main topic to be covered in the Monday forenoon session and "Bulk Handling of Milk" is scheduled for the Monday afternoon session. Other specific topics to be included in the Rural Electric program include "Effect of Environment on Livestock and Poultry",

"Effect of Grain Grinding Methods on Feed Consumption of Beef Cattle", "Effect of Temperature and Relative Humidity on Market and Hatching Eggs During Short Holding Periods", "Why Should Agricultural Engineers be Interested in Electric House Heating?", "A New Approach to Animal Shelter Cooling", "Requirements of Standby Generators for Farms", and "On-the-Farm Grain Drying and Storage".

A joint meeting, arranged and sponsored by the Committee on Agricultural Processing, is planned for Tuesday forenoon, December 13, with the Rural Electric Division. Carl W. Hall, chairman, Committee on Agricultural Processing, (associate professor, agricultural engineering, Michigan State University) will preside. Fred C. Winter, industrial engineering department, Columbia University, and consultant, transportation and facilities branch (AMS) USDA, will open the session with a paper on "Approach to Different Methods of Efficiency

(Continued on next page)

## With the ASAE Sections

### Connecticut Valley Section

A meeting of the Connecticut Valley Section is planned for October 13 at Publick House, Sturbridge, Mass. The program will be highlighted by a report by Carl F. Libby, Northeast Agricultural Engineering Service, on consulting engineering in the farm structures field. The report will contain interesting information regarding hurricane damage, pole structures, and other timely topics.

### Georgia Section

"The Advancement of Georgia Agricultural Engineering Research" is the theme of a meeting of the Georgia Section to be held October 13 and 14 at the Coastal Plain Experiment Station, Tifton.

On Thursday afternoon, F. P. King, resident director, will present a review of the research program at the Coastal Plain station. Following the review, a tour of the station and an explanation of the projects will be directed by members of the station staff. The program for Friday morning will include a tour of the soil conservation station, a field trip to a farm reservoir which uses an electric pump for irrigation water supply, and a field trip to observe engineering phases of a conservation plan on cropland. A buffet dinner is planned for Thursday evening.

### Florida Section

A meeting of the Florida Section will be held October 14 and 15 at the University of Florida, Gainesville. This meeting is planned to coincide with the dedication of the new agricultural engineering building. The dedication will be held October 15. National ASAE President Wayne H. Worthington will speak at the dedication ceremony.

### Chicago Section

A tour of the Caterpillar Tractor Co. works at Joliet, Ill., is planned for the Chicago Section meeting to be held October 17 beginning at 10:00 a.m.

A discussion on future power requirements on the farm will be presented by a representative of the Caterpillar Tractor Co. A short film and a business meeting will precede the tour. The tour will be completed by 3:15 p.m.

### Pacific Northwest Section

A meeting of the Pacific Northwest Section will be held October 19 to 21 at the Heathman Hotel, Portland, Ore. The program will feature such speakers as Wayne H. Worthington, national ASAE president; the Honorable Paul Patterson, governor of Oregon; F. Earl Price, dean of agriculture at Oregon State College, and Ace Clark, well-known Washington farmer who was one of the 12 United States farmers taking a tour of Russia this past summer.

Topics covered in the meeting sessions will include "The Use of Adhesives in Farm Structures," "Tillage Practices and Irrigation," and "Automation—Maneater or Friend."

A full program is planned for the ladies.

### Minnesota Section

A meeting of the Minnesota Section will be held at the Minnesota Mining and Mfg. Co., 2301 Hudson Rd., five miles east of St. Paul, October 20. The program will begin with an inspection tour of the company's

research building at 4:00 p.m. It will be followed by a dinner and business meeting. The program will include talks by Vernon Meyer, agricultural engineering department, University of Minnesota, entitled, "Application Equipment for Anhydrous Ammonia and Solution Nitrogen", and by Willard Cochrane, professor of agricultural economics, University of Minnesota, entitled "Farm Technological Advances and Surpluses."

### Pennsylvania Section

A meeting of the Pennsylvania Section will be held October 20 and 21 at the Holiday Motor Hotel, Gettysburg Interchange, Harrisburg. The tentative program includes the following subjects: Pole-type buildings, adapting steel buildings to new trends in agriculture, Hurricane Hazel damage to farm structures, painting galvanized roofing, water resources in Pennsylvania as affecting irrigation, lighting as affecting plants, performance of new experimental frozen food cabinets, panel on forage harvesting, research in drying hay, and crop drying principles versus systems.

Plans are being made to include a tour of the Ralston Purina mill.

### Alabama Section

A meeting of the Alabama Section will be held October 21 and 22 at Alabama Polytechnic Institute, Auburn. Registration and serving of coffee will begin at 10:00 a.m. on the first day. A chicken Bar-B-Q is planned for lunch. In the afternoon, the group will see an automatic feed processing set-up, an outdoor brooder, the new educational TV station and will visit the dairy processing plant and the small animal clinic. A banquet will be held at the Pitts Hotel Friday night.

On Saturday morning a business meeting will be held, followed by a tour of the Wimber Engineering Laboratory. In the afternoon Auburn will meet Furman at Cliff Hare stadium in a football game.

### Michigan Section

A meeting of the Michigan Section will be held October 22 at East Lansing. The program theme is "Future Machines and Methods in Corn Production." H. J. Barre, consulting agricultural engineer, will talk on materials handling in corn production; R. Cook, head, soils department, Michigan State University, will discuss machines required for new cultural practices in corn production; C. S. Morrison, Deere and Co., will talk on new harvesting machines and methods, and W. V. Hukill, Agricultural Research Service, USDA, will discuss the drying and storing of corn.

The ladies will be entertained by an illustrated lecture on new clothing fabrics. In the afternoon the homecoming football game will be played between Michigan State and University of Illinois.

### Quad City Section

A dinner meeting of the Quad City Section will be held at 6 p.m., November 4, at The Tower, Moline, Ill. The program following the dinner will consist of a paper on automatic feed grinding on the farm by Martin A. Berk and Murray W. Firth of Deere and Co., and a talk by E. G. McKibben, chief, agricultural engineering research branch (ARS), U. S. Department of Agriculture, on the subject of agricultural machinery research in the USDA.

Reservations for the dinner should be mailed to W. L. Stevenson, J. I. Case Co., Rock Island Works, Rock Island, Ill.

### Virginia Section

A meeting of the Virginia section will be held November 4 and 5 at Hotel Roanoke, Roanoke. A technical program is being planned and members will be brought up-to-date on the plans and developments for the ASAE Annual Meeting in June of next year. National ASAE President Wayne H. Worthington and Past-President George B. Nutt will take part in the program.

On November 5 a football game will be held between VPI and Clemson College.

### Ohio Section

A meeting of the Ohio Section was held October 7 and 8 at Ohio State University, Columbus. The theme of the program was "How Agricultural Engineering Can Help Solve Farm Problems." Friday afternoon panels with R. D. Barden as moderator included the subjects of "What's New in Agricultural Engineering?" and "What Are the Principal Agricultural Engineering Problems in Farm Operation?" Virgil Overholt served as moderator of a panel on "Irrigation Problems in Ohio Agriculture" during the morning program of October 8.

Ferris Owen, Newark, Ohio, farmer who toured Russia this past summer was principal speaker at the Friday evening banquet. A football game between Ohio State and University of Illinois was the main attraction during the afternoon.

### 1955 Winter Meeting Program (Continued from page 676)

Studies". Other papers on the program will include "Forage Handling and Feeding with Conveyors" by B. F. Cargill, Michigan State University; "Handling Seed Cotton and Cotton Seed at Gins" by Charles M. Merkel, U. S. Cotton Ginning Research Laboratory, Stoneville, Miss.; "Materials Handling in Poultry Industry" by P. D. Rogers, Rex Childs and Harold White, University of Georgia; "Problems in Design and Application of Equipment for Conveying Grain In and Out of Flat Bottom Steel or Wood Grain Storage Buildings" by Robert I. Paine, McRan Co., Tex.; and "Distribution of Bibliography of Materials Handling Equipment for Agricultural Products" by Carl W. Hall, Michigan State University.

#### Education and Research Program

Tuesday afternoon, December 13, has been reserved for a general meeting of wide interest arranged by the Education and Research Division.

The proposed program as reported by F. A. Kummer, chairman, Education and Research Division (head, agricultural engineering, Alabama Polytechnic Institute), will be devoted to the subject of "Automation."

A paper by Dr. Eric A. Walker, dean, school of engineering and architecture, Pennsylvania State University, entitled "Automation—Engineering for Tomorrow", will open the program. His talk will be followed by lantern slides on "Automation—A Look Into the Future".

A panel discussion is planned to complete the program. The proposed list of panel members include A. R. Satullo, The Satullo Co., to discuss "Instrumentation for Automation"; Eivind Hognestad, manager, Structural Development Section, Portland Cement Association, to discuss "Automation Techniques in the Design and Construction of Concrete Buildings"; and Frank Babcock, executive director, Universal Materials Handling Corp., to discuss "Automation Techniques in Materials Handling". Substitutions may be required because all panel members have not confirmed their invitations.

**D. M. Burns**, former associate agricultural engineer at the experiment station, Hawaiian Sugar Planters' Association, Honolulu, has resigned to accept the position of automotive superintendent with the Kaiwai Sugar Co., Ltd., Oookala, Hawaii.

**William D. Hanford** has joined the editorial staff of *Farm Implement News*, Chicago, as an assistant editor. He is a graduate in agricultural engineering from Oklahoma A. & M. College and has been with International Harvester Co. for the past five years as a field engineer and layout draftsman at McCormick Works in Chicago.

**Kern C. Olson**, who has been employed as a farm structures representative of Weyerhaeuser Sales Company, is now employed by Rilco Laminated Products, Inc., First National Bank Bldg., St. Paul, Minn.

**Darwin E. Wendland** has resigned as junior engineer with the Minneapolis-Moline Co., Hopkins, Minn., and is now residing at Balaton, Minn. He plans to enter a seminary this fall.

**Ross D. Brazee**, who has been on duty with the armed services, is now associated with the agricultural engineering department, Michigan State University, East Lansing.

**William T. Mills**, who received his master of science degree in agricultural engineering from North Carolina State College, has been appointed research instructor in agricultural engineering at that institution. He will be in charge of and devote full time to problems of mechanizing production and harvesting of peanuts in North Carolina.

**Victor G. Fuhrwerk** has resigned as product test engineer, International Harvester Co., to become senior project engineer with New Idea Farm Equipment Co., at Coldwater, Ohio.

**Bruce R. Anderson**, formerly with Western Michigan Electric Coop, is now employed as sales engineer, American Blower Corp., Detroit.

**Lambert H. Wilkes** has accepted an appointment to the agricultural engineering staff at New Mexico A. & M. College, State College. He will be engaged in research work in cotton mechanization and in the development of improved methods and equipment for planting and weed control in cotton production. He will also teach power and machinery courses part time.

**Morris E. Schroeder** has completed a tour of active duty in the Army and has accepted an appointment to the agricultural engineering extension staff at Pennsylvania State University.

**Willard H. Loper**, formerly employed by Cochran Motors Co., has joined the agricultural engineering staff at California State Polytechnic College, San Luis Obispo.

**L. LeRoy Reaves**, recently associated with an office and engineering supply firm in Lancaster, Calif., has been appointed to the staff at California State Polytechnic College, San Luis Obispo, as an instructor in agricultural engineering.

## ASAE MEMBERS in the News

**Frank H. Hamlin** (Member ASAE since 1932) has been elected president of the Farm Equipment Institute at its 62nd Annual Meeting in New Orleans, September 18 to 21.

Mr. Hamlin, president of Papec Machine Co., Shortsville, N. Y., joined the Papec company in 1924 as a sweeper at \$15.60 per week. He held other summer jobs in various parts of the Papec plant while attending Yale University. After his graduation, in 1928, he joined the Papec office staff. He became vice-president in 1940, general manager in 1947 and was elected president in 1953.

Mr. Hamlin is a past-chairman of the North Atlantic Section of ASAE, a member of the joint committee on grassland farming and is a former chairman of the executive committee of FEI.

**Vernon H. Baker** and **Dennis E. Wiant** of the agricultural engineering departments of Virginia Polytechnic Institute and Michigan State University, respectively, presented a paper on a symposium held at the Mayo Clinic, Rochester, Minn., last month, entitled "Some Effects of Electro-magnetic Energy on Biological Material," which included data on the effects of microwaves on insects prepared in cooperation with the Raytheon Mfg. Co. The symposium, of which the physiological and pathological effect of microwaves was the main topic, was sponsored by the Biophysics Section of the Mayo Clinic in cooperation with the Sandia Corp. of Albuquerque, N. M. The symposium was attended by physicists, radar experts, electronic engineers, biophysicists, doctors of medicine, members of the armed forces, and representatives from educational and industrial organizations.

**Curtis A. Johnson**, formerly instructor in agricultural engineering, Iowa State College, is now on an assignment with the International Cooperation Administration at Kuetta in the state of Baluchistan, Pakistan. He is assisting with farm machinery and related problems for a new agricultural engineering workshop in that area.

**H. W. Kitching**, who recently completed an assignment as farm machinery adviser to the government of Pakistan under the Colombo Plan Technical Assistance Program, has accepted the post of farm machinery specialist under the expanded technical assistance program of the Food and Agriculture Organization of the United Nations (FAO). His headquarters will be in Rome where he will work with the agricultural engineering subject-matter group of the Agriculture Division.

**Ross A. Phillips**, until recently employed as development engineer by the F. E. Myers & Bro. Co., has accepted an appointment for teaching and research in the agricultural engineering department of West Virginia University, Morgantown.

**Oscar W. Sjogren**, a past-president of ASAE and for several years, prior to his retirement last year, a consulting agricultural engineer of the John Deere Killefer Division of Deere & Company, is now on a temporary assignment with California State Polytechnic College, San Luis Obispo. He is acting as coordinator for a group of 13 men from 9 foreign countries who are participants in a special training course in farm mechanization sponsored by the International Cooperative Administration in cooperation with the U.S. Department of Agriculture and land grant colleges.

The group consists of men who hold responsible positions in their respective countries—four from Yugoslavia, two from Iran and one each from Brazil, Chile, Greece, Spain, Ecuador, China and Indonesia.

The course includes five weeks in California, two weeks at Montana State College, two weeks at Ohio State University, and then to Washington, D. C.

**John E. S. Palmer**, agricultural engineer in the colonial service of the British Government, has been transferred from his former assignment with Samaru, in northern Nigeria, to similar work with Mokwa, a colonial development corporation operation recently taken over by the government, and located in Niger Province, Northern Nigeria.

**Kenneth D. Grosse**, until recently employed as a standards engineer by the Heil Co., Milwaukee, is now connected with the export sales department of Caterpillar Tractor Co. at Peoria, Ill.

**George H. Larson** has completed requirements for the Ph.D. degree in agricultural engineering at Michigan State University and has returned to Kansas State College to resume his duties in the agricultural engineering department.

**Norman H. Foote** is to be on leave for the next two years from his position as head of agricultural engineering at the Long Island Agricultural and Technical Institute, Farmingdale, N. Y., to carry out an agricultural engineering assignment in Israel. His headquarters will be the American Embassy in Tel Aviv.

**Norman L. Slack** has resigned as test engineer for the International Harvester Co. to accept a similar position, with specialization in stress analysis, with LeTourneau-Westinghouse Co., Peoria, Ill.

**Paul B. Shutt**, who has been serving as an engineering trainee with the New Holland Machine Division of Sperry Rand Corp., has recently taken an engineering position with the Lakeshore Division, Bending Aviation Corp., St. Joseph, Mich.

**James T. Reid** has resigned as an instructor in agricultural engineering at West Virginia University, to accept an appointment with the agricultural engineering department of the Georgia Experiment Station at Experiment, Ga.

**Ernest A. Johnson**, who has been engaged in dairy farming at Petersham, Mass., has accepted appointment as an agent of the U.S. Department of Agriculture to engage in rural electrification research. He will be stationed at the agricultural engineering department of Purdue University, Lafayette, Ind. (Continued on page 680)

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## ASAE Members in the News

(Continued from page 678)

**Allison K. Simons**, chief engineer, Bostrom Mfg. Co., Milwaukee, presented a talk before the Allis-Chalmers Engineering Society meeting in the Allis-Chalmers club house, Milwaukee, September 21. The subject of his talk was "Professional Development," in which he discussed the responsibilities of professional engineers to the community.

**R. Bruce Curry** recently completed work for his master's degree in irrigation engineering at Colorado A & M College, and has accepted a position as instructor in the agricultural engineering department at the University of Missouri. In addition to teaching irrigation and drainage subjects he will be doing research and taking work for credit toward a Ph.D. degree.

**Gerald S. Birth**, recently employed as graduate assistant in agricultural engineering at Michigan State University, is now assistant agricultural engineer in the USDA agricultural engineering laboratory at Beltsville, Md. He will be engaged in research work in color sorting of fruits and vegetables.

**C. Robert Powers**, formerly employed by the Greening Smith Co., Norwalk, Calif., is now associated with the Mercer-Robinson Co., 30 Church St., New York City.

**Thomas R. C. Rokeby** has resigned as assistant professor of agricultural engineering, South Dakota State College, to accept a similar appointment in the agricultural engineering department of the University of Arkansas, Fayetteville.

**William C. George**, formerly of the University of Arkansas, has accepted a teaching position in agricultural engineering at Western Illinois State College at Macomb. He will teach elementary agricultural engineering, agricultural machinery, farm shop and farm buildings.

**Leonard M. Bumm**, formerly a fruit and produce inspector for the Federal Railroad Perishable Inspection Agency, is now employed as an engineer trainee by the New Holland Machine Co., New Holland, Pa.

**Joe T. Clayton** has resigned as assistant professor of agricultural engineering, University of Connecticut, to accept a similar position in the agricultural engineering department, University of Illinois.

**Joseph Coulam**, who has been on a United States operations mission to Surinam, has been transferred to a similar assignment in Chile and will be located at the Institute of Inter-American Affairs at Santiago.

**C. L. Day**, associate professor of agricultural engineering, University of Missouri, will be on sabbatical leave this coming year, during which he will be doing graduate work in agricultural engineering at Iowa State College.

**P. John Zachariah** has resigned as manager of the tractor division of Stanes Motor Co. of South India and is now at the agricultural engineering department, West Virginia University, Morgantown, where he is working for a master's degree in agricultural engineering.

## Six Elected ASAE Fellows

The Council of ASAE recently has elected the following members to the grade of Fellow in the Society: H. L. Garver, R. B. Gray, E. W. Hamilton, W. V. Hukill, W. M. Hurst and G. B. Nutt.

**HARRY L. GARVER** received a B.S. degree from the State College of Washington in 1922. In 1925 he joined the staff of the Washington Agricultural Experiment Station and spent 12 years investigating the application of electricity in agriculture. During this time he also earned a degree in electrical engineering. In 1936 he began a year and one-half in graduate work at the University of California. He joined the U.S. Department of Agriculture in 1938 and became engineer in charge of design, construction and operation of 42 hemp mills located in six states in 1942. In 1953 he was put in charge of livestock housing studies, farm building section, (AERB, ARS) U.S. Department of Agriculture.

**ROY B. GRAY** received B.S. degrees in electrical engineering in 1909 and agricultural engineering in 1910 from Iowa State College. After graduation he was an experimental tractor engineer with International Harvester Co., mostly in foreign countries. In 1921 to 1924 he was in charge of the department of agricultural engineering at the University of Idaho. He began his present connection with the U.S. Department of Agriculture in 1925 when he became head of the division of farm machinery in the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Among many activities he has directed, of particular interest is his participation in the planning and establishment of the tillage machinery laboratory at Auburn, Alabama.

Mr. Gray served as chairman of ASAE Power and Machinery Division in 1933-34 and of the Washington, D. C., Section in 1941-42. He received the John Deere medal in 1950. He at one time received the decoration of "Officer du Merite Agricole" from the French government for recognition of services rendered to French agriculture.

**ELMER W. HAMILTON**, (ASAE Member since 1908) as a result of his election to the grade of Fellow, will become a Life Fellow of ASAE. Mr. Hamilton was born on a farm near Arena, Wis. He received a B.A. degree from the University of Wisconsin in 1904. During his University days he operated a steam traction engine in autumn on a threshing outfit and did considerable writing for *The American Thresherman*. Upon graduation he became editor of *The Canadian Thresherman* in Winnipeg, Manitoba. In 1908 he initiated the Winnipeg Industrial Exhibition Association. Contests conducted by the association made early tractor history by providing farmers, tractor manufacturers and agricultural engineers an opportunity to compare types, sizes and designs of tractors in the field and on the belt. In 1910, Mr. Hamilton took over the management of *The Canadian Thresherman and Farmer* and continued as editor until it was discontinued in 1924. He returned to Madison, Wis., to write for *Gas Review* and *The American Thresherman*. He later became editor. In 1939 he joined Allis-Chalmers Mfg. Co. to work on grasses, silage, hay and pastures and to follow development of mechanized forage handling equipment.

In 1941 he was one of the founders of the joint committee on grassland farming. At present he is writing a book on "Man and the Grasses" for the Allis-Chalmers Mfg. Co.

**WILLIAM V. HUKILL** was born in Corvallis, Oregon. He graduated from Oregon Agricultural College in 1923 with a B.S. degree in mechanical engineering. After graduation he served as chairman of a lumber company until he joined the U.S. Department of Agriculture in January, 1924. With the U.S. Department of Agriculture at Washington, D. C., he was with the Bureau of Public Roads, Bureau of Agricultural Engineering, Bureau of Agricultural Chemistry and Engineering, working in research on transportation and storage of fruits and vegetables and on farm buildings. In 1941 he was assigned to Wenatchee, Washington, for research on cold storage of apples and pears. In 1943 he transferred to Ames, Iowa, with the Bureau of Plant Industry, Soils and Agricultural Engineering and Agricultural Engineering Research Branch, for research on grain drying and storage. His work in grain drying and storage has been outstanding and his contributions to agricultural processing have been numerous.

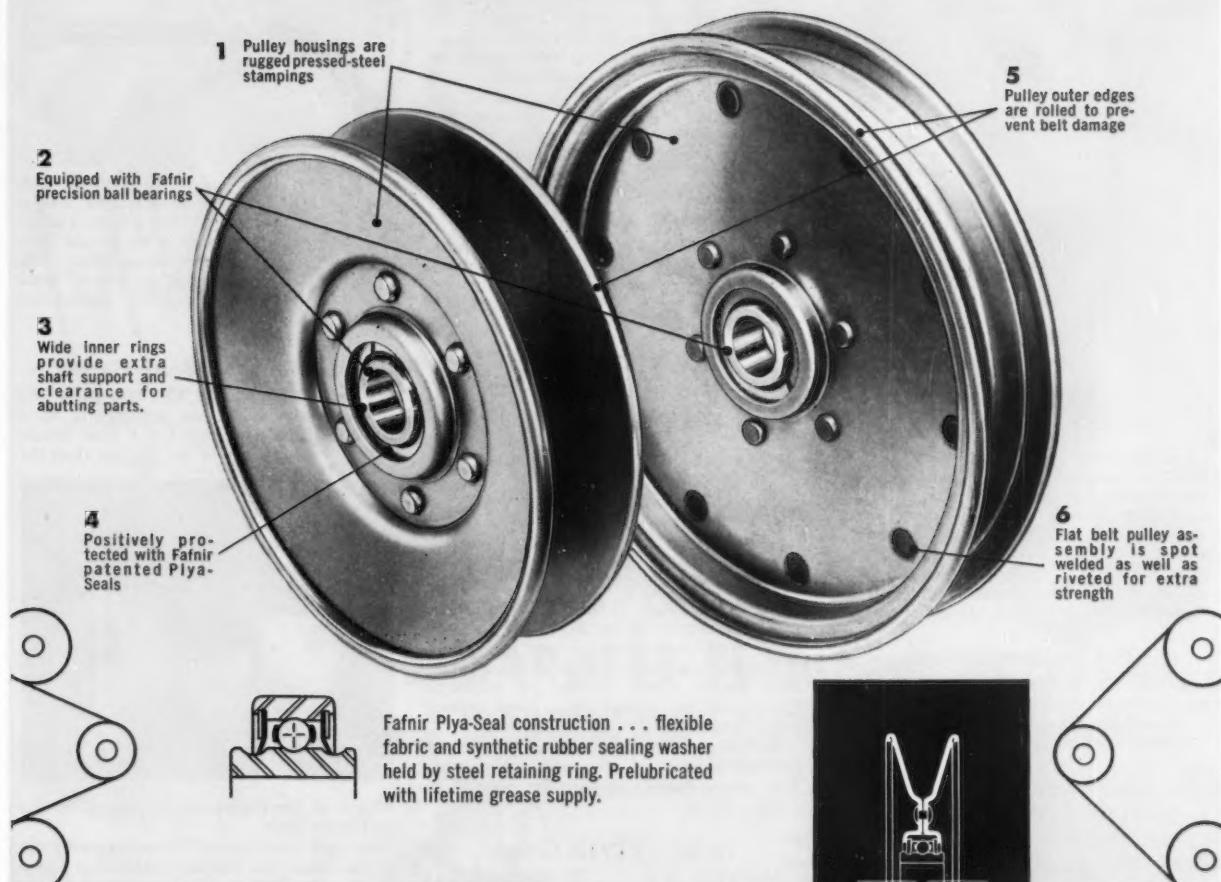
**WILBUR M. HURST** received a B.S. degree in agriculture from the Mississippi State College in 1923 and a B.S. degree in agricultural engineering from Iowa State College in 1925. During the period from 1926 to 1938 he served in the farm machinery division, U.S. Department of Agriculture. At the time of his transfer to a field station in 1938 he was assistant to the farm machinery division chief. Since then he set up a project on fiber flax processing in cooperation with the Oregon Agricultural Experiment Station and flax mills. During World War II he was sent to Cuba for a short period to assist in working out a cooperative project on the production and processing of jute substitute fibers. In 1945 he was transferred to the Beltsville office and assigned to a cooperative project between the BPISAE and the Farm Credit Administration for research and technical assistance on problems of an engineering nature faced by farmers' cooperatives. In 1952 he was made section head of mechanical preparation and conditioning section (AERB, ARS), U.S. Department of Agriculture.

**GEORGE B. NUTT**, immediate past-president of ASAE, received a B.S. degree in agricultural engineering at Mississippi State College in 1930. After two years with International Harvester Co., he joined the staff at Clemson Agricultural College as an associate professor of agricultural engineering. He received an M.S. degree from Iowa State College in 1940 and became head of the Clemson agricultural engineering department the following year. In July of this year he was named director of the Clemson Agricultural Extension Service.

During 1944 he served on a special assignment with the U.S. Department of Agriculture Office of Foreign Agricultural Relations for work as senior agricultural engineer in charge of research and station development along agricultural engineering lines in cooperative experiment stations in Latin America. In 1950 and 1951 he was a consultant to the International Bank for Reconstruction and Development and studied conditions in Iraq, Syria and Paraguay.

He has served as chairman of the Society's agricultural engineering teaching seminar, vice-chairman and chairman of the College Division, chairman of the Southeast Section, and was ASAE president during 1954-55.

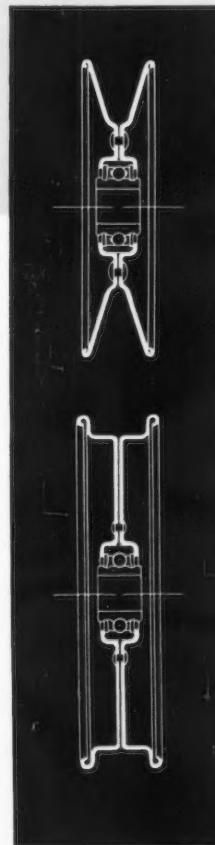
# NEW! FAFNIR BALL BEARING IDLER PULLEY ASSEMBLIES



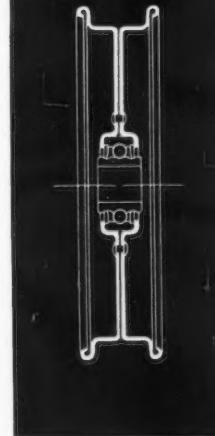
In addition to setting a new standard of performance, these Fafnir Pulley Assemblies are easier to install, easier on belts, and require no adjustments or relubrication. They offer new design refinements for the manufacturer of such equipment as combines, hay balers, corn pickers, forage harvesters, grain elevators —plus cost and labor savings for the farmer. A money-saving replacement for inefficient pulleys. Write for new bulletin containing descriptive details and dimensions. The Fafnir Bearing Company, New Britain, Connecticut.

**FAFNIR**  
BALL BEARINGS

MOST COMPLETE LINE IN AMERICA



Idler Pulley Assembly for  
**V-BELTS**  
Pulleys are 5 1/4" in diameter.

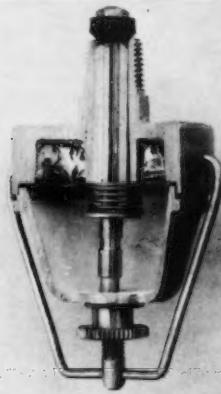


Idler Pulley Assembly for  
**FLAT BELTS**  
Pulleys are 6 1/4" in diameter.

### New Fuel Filter

Collis Enterprises, Inc., P.O. Box 577, Mundelein, Ill., has announced production of a new fuel filter for all gasoline engines, diesel engines, oil burners and space heaters.

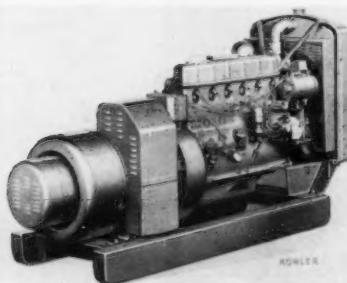
The new filter, called the S.C.A.B. fuel filter, is said to be non-clogging, non-dripping, fire-closing and freeze-proof. A



neoprene valve closes when the sediment bowl is removed or when sand or other particles are present. A fusible plug, capable of melting at low temperatures, automatically shuts off fuel in case of engine fire. A metal sediment bowl is designed to eliminate damage from freezing. Straight-through design reduces the possibility of clogging. When servicing, no tools are necessary.

### 35-KW Electric Plants

Kohler Co., Kohler, Wis., has announced production of two new 35-kw electric plants. One of the plants has a rated capacity of 35,000 w of alternating current and is diesel-



powered. The other new unit also produces 35,000 w of alternating current and is powered by gasoline.

All models in diesel and gasoline-driven units feature remote-controlled, electric starting by "on-off" switch at the plant or two-wire remote control. Starting panels are equipped with overcranking protection. The units are cranked electrically through automotive-type starting which uses a 12-v starting battery. Wall-mounted transfer switches for automatic stand-by operation are available for both the gasoline and diesel models.

The diesel-powered model is equipped with a Waukesha model 195 DLC 6-cylinder, liquid-cooled engine with 4-in stroke and bore. They develop 75 hp at the governed speed of 1800 rpm.

The new gasoline-powered models have Waukesha Model 195 GK 6-cylinder, liquid-cooled engines with 4-in stroke and 4 1/8-in bore and develop 81.5 hp at 1800 rpm.

## NEW PRODUCTS CATALOGS

### Free Machine Shed Plan

The Farm Service Bureau, Masonite Corp., 111 West Washington St., Chicago 2, Ill., will send at no cost to interested readers a working drawing showing construction details of a 30 x 48-ft pole-type machine shed. The structure is post-free and offers easy construction with panels of Masonite tempered preswood. Suggestions are included also for a repair shop with space for hanging tools on pegboard panels.

### PTO Irrigation Pumps

Carver Pump Co., Muscatine, Ia., announces a new complete line of PTO pumps specifically designed for sprinkler irrigation.

Made in two sizes (3 and 4-in discharge) they range in capacities up to 600 gpm and



heads up to 200 ft. The 3-in pump can be used on tractors up to 20 hp and the 4-in pump is rated at 28 hp.

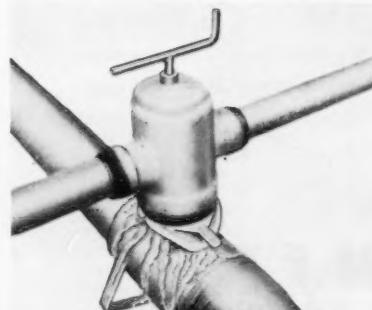
These pumps can be coupled to any standard tractor PTO. Drives are enclosed. Pumps can be primed by a hand-priming pump which is standard equipment.

Pumps are also furnished in V-belt and gear-driven units on carts with rubber tires. The geared units can also be used on a 3-point hitch.

### Irrigation Drain Collar

McDowell Mfg. Co., Pittsburgh 9, Pa., has added to its line of irrigation couplings and fittings a new drain collar for draining lateral lines and relieving back pressure in portable irrigation systems.

The new collar is applicable for use with both single and two-way McDowell hydrants. Installation involves only the removal and replacement of a screw and the



positioning of the collar inside the hydrant. It can be done in a matter of a few minutes, it is said.

To operate the drain collar, it must be turned, which will raise the hydrant to provide maximum drainage of lateral lines and removal of the hydrant.

### Sprayer for Udder Washing

Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., has announced a new sprayer designed for washing cows' udders prior to the attachment of milking machines.



This new washer can be operated with one hand and consists of a trigger TeeJet with garden hose connection, a curved adaptor, and a TeeJet nozzle with special full-cone spray tip for best washing effect. The No. 5997 washer is made entirely of brass and can be used for other agricultural spray uses.

### Flexible-Shaft Brush Cutter

Stow Manufacturing Co., 39 Shear St., Binghamton, N. Y., has designed a 1/2-in flexible shaft especially for a new brush-cutting tool. By use of the flexible shaft the



weight of the engine can be carried on the operator's back.

A rigid shaft inside a tube transmits the power from the flexible shaft to a right-angle gear box at the saw.

### Rubber Hose Catalog

Industrial Rubber Division, The Thermod Co., Trenton, N. J., has released a new 8-page catalog digest which presents specifications and descriptions of 68 different rubber hose for industrial and agricultural use.

In addition, the brochure contains data on nine types of conveyor belts, seven types of flat power-transmission belting, multiple and fractional horsepower V belts, chute lining, rubber sheet packing and industrial friction materials. Cutaway photographs show hose, coupling and belt construction.

### New Motors Pamphlet

Merkle-Korff Gear Co., Chicago 7, Ill., will send on request its new 4-page pamphlet on Merkle-Korff fhp geared motors.

The illustrated, two-color pamphlet describes and gives specifications, types, speeds, gears and applications of the company's line of geared motors. The types of motors described include a-c induction motors, synchronous motors, and universal a-c or d-c motors, or for variable speed applications. Direct-current motors are also described. Reversing motors are available for each type of motor. (Continued on page 684)

DURKEE-ATWOOD's Little Professor reports . . .

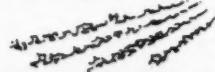
"Sugarbeets...1000's of 'em..."

harvested automatically with  
**BLACKWELDER'S** amazing  
**MARBEET HARVESTER...**  
for as little as 45¢ per ton!"

One man . . .



harvests 3 to 5  
acres per day . . .



delivering up to  
100 tons . . .



of clean topped  
beets!



Blackwelder Engineers also  
use Durkee-Atwood V-belts for  
this completely portable  
Schmidt Ditch Pump



High efficiency at low maintenance cost  
is achieved in this completely portable  
self-contained unit through the use of  
Durkee-Atwood Multiple V-belts. One  
man can set up the pump in 5 minutes  
anywhere, ready to deliver up to 3200  
G.P.M. from depths varying from 3 to  
9 feet. Another example of how Durkee-  
Atwood V-belts help deliver peak per-  
formance. Let D-A engineers help you  
with your transmission design.



## The MARBEET Sugarbeet Harvester uses DURKEE-ATWOOD V-belts!



Blackwelder engineers saved beet farmers plenty of money when they designed the MARBEET. Now in use across the U.S. and abroad, this rugged machinery harvests *all* the beets, large and small, and delivers them *clean*. The MARBEET's unique power transmission and take-off network calls for top-flight performance. That's why Blackwelder engineers called on Durkee-Atwood for assistance in designing the rugged but gentle, foolproof and efficient transmission system. And that's why the MARBEET uses tough, long-lasting Durkee-Atwood V-belts exclusively . . . to keep beet harvesting costs low . . . even under wet and adverse conditions. Call on D-A . . . let Durkee-Atwood V-belt engineers help you with tough transmission problems.



### ATTENTION AG. ENGINEERS—

Get your **FREE** copy of  
"Handy Tips on V-belts  
and V-belt drives"

See your D-A distributor or write Dept. AE-10  
for catalog that includes conversion tables,  
engineering data, latest Rubber Manufacturers  
Association horsepower ratings, drive  
selections and helpful Do's and Don'ts of  
V-belt operation.

**DURKEE-ATWOOD**  
COMPANY

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**DURKEE  
ATWOOD  
V-BELTS**

## New Products and Catalogs

(Continued from page 682)

### New Corn Picker

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has introduced its new Model 33, two-row tractor-mounted corn picker designed especially for mounting on WD-45, WD, and WC tractors.

The new picker uses a new husking principle of rubber-on-rubber with 52 husking plugs of special long-wearing rubber on one roll to mesh with matching recesses on the opposite roll. The 4-blade rotary feeders, one above each set of husking rolls, regulate and maintain a uniform flow of ears across the rolls to help prevent slugging and to speed trash removal.



New outer stripping plates over the snapping rolls are adjustable with a handy lever at the operator's left hand. This makes it possible to regulate instantly the opening over the snapping rolls to accommodate changing stalks and ear sizes while picking.

Mounting or removal of the picker from the tractor can be done by one man without the need of a hoist.

Specifications include row spacings, 41-in centers (38 to 44-in rows); over-all width, 7 ft, 8 in; over-all length with elevator, 23 ft, 11 in; over-all height, 10 ft, 3 in; transport clearance, 7 1/2 in; and weight is approximately 1850 lb.

### New Adjustable Rear Blade

Tractor and Implement Division, Ford Motor Co., Birmingham, Mich., has announced a 6-foot adjustable rear blade designed to mount on all Ford tractors and featuring tilt, pitch and offset adjustments as well as blade angling.



The new blade angles 45 degrees each side of center with 7-hole stops, and tilts 40 degrees each side of center with 9 holes. Blade pitch is adjustable to 10 degrees plus or minus by means of an adjustment at the rear of the blade, with intermediate pitch adjustments made with the tractor's adjustable top link.

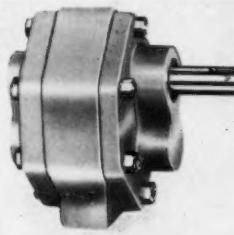
Available as accessories are gage wheels, end plates, skid shoes and ditching points.

A high-carbon steel cutting edge is reversible and replaceable.

Cutting and over-all width are 72 in; transport clearance when raised by the tractor hydraulic system is 18 in; over-all length is 48 in, over-all height is 48 in, blade height is 17 in, and weight is 360 lb.

### Hydraulic Pumps

Wisconsin Hydraulics, Inc., 3165 North 30th St., Milwaukee 16, Wis., has announced a new line of five gear-type pumps. Rated

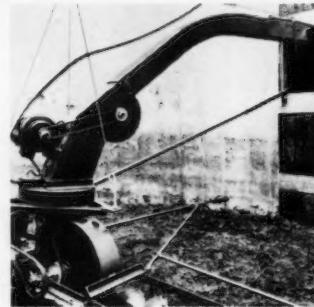


for 1000 psi continuous duty, the pumps are made in five sizes, with discharge capacities from 8 up to 22 gpm. Pumps are available in a variety of flanges, mountings and portings.

### New Silo Unloader

Starline, Inc., Harvard, Ill., has introduced a new silo unloader for handling both frozen and unfrozen silage.

Off-center suspension, by a steel cable and tripod, utilizes the weight of the unloader to keep the wall cleaners working close to the wall, even if the silo is out-of-round. A winch raises and lowers the unloader.



Silage is not blown, but is thrown out of the discharge spout. Hammers of the first impeller throw the silage up the chute from the augers and the paddles of the second impeller throw it out the discharge spout.

The new unloader is manufactured under agreement with Van Dale Farm Machines, Inc.

### New Grease Guns

Lincoln Engineering Co., 5702-6 Natural Bridge Ave., St. Louis 20, Mo., has announced two new lever grease guns equipped with either a rigid hydraulic coupler extension for contacting hydraulic fittings, or with a flexible 12-in hose extension with a special coupler for contacting

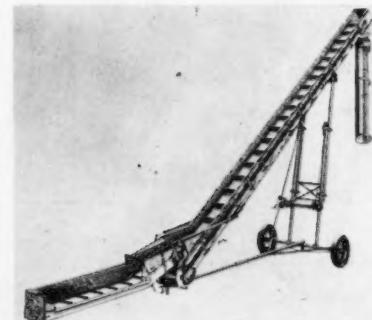


button-head grease fittings. The new guns are designed to deliver 0.17 oz per stroke, or 6 strokes per ounce using No. 1 cup grease at 70 F. Guns may be spring or force primed, hold 21 oz of lubricant and include filler nipple for refilling from a filler pump or by suction. Construction is all steel, rustproofed and finished in metallic gun-metal blue.

### Portable Farm Elevator

Allis-Chalmers Mfg. Co., Milwaukee, Wis., announces addition of the Flight Line portable elevator to its line of agricultural implements. It is powered either by the tractor PTO, portable engine or electric motor.

The elevator handles corn, loose grain, baled hay and silage into crib, bin or mow. Design features include a double-X trussed steel framework construction and a spring-balanced feeder with either 8-ft or 11-ft hopper. The elevator also has a 50-in-wide shovel hopper for use when working in



restricted areas; adjustable bale chute; 15 1/2-in-diam spout 5 ft long, with extensions available in 4-ft sections. The unit has an automotive-type speed reducer, V-belt drive, and is oil-bath lubricated. Roller bearing wheels have drop-center rims for 6.00 x 16 tires. The wheel tread of the unit is 6 ft. Models are available in lengths from 26 to 50 ft.

### Capscrew Selection

Because assembly cost often counts more than the purchase price of the fastener, designers and purchasing agents should look to the assembled cost in selecting fasteners, advise Russell, Burdsall & Ward fastener specialists. In selecting capscrews, for example, compare heat-treated and bright-finish types on the basis of physical properties. The color of capscrews signifies their physical properties. Bright capscrews get their color and shiny appearance from cold working. For many applications, bright capscrews, with their close tolerances, accurate threads and excellent appearance, are ideal.

Black capscrews with three radial dashes on top of the head get their color—and their combination of strength and ductility—from their high-carbon content and from heat treatment. They afford greater toughness for jobs where high stresses will be encountered.

Heat-treated capscrews can stay tighter than bright capscrews, point out the company technicians. Holding power of a fastener depends on residual tension, which is dependent upon tensile strength. High-carbon heat-treated capscrews, because they have greater tensile strength, are capable of being stressed much higher than bright capscrews. If a joint is loosening, often the cure can be found in a black heat-treated capscrew tightened to set up the correct residual tension.

Though initial cost of heat-treated capscrews is greater than the bright finished type, they can often cost less than bright ones, particularly if holding power is the important quality needed. For example, to obtain a safe working load of 20,000 lb, you can use a 3/4-in bright capscrew or a 3/8-in black capscrew. The smaller screw, heat-treated, costs less than the larger bright one.

DON'T LET YOUR SOIL  
"Run for Cover"



*Provide a Good Cover Crop*  
**with a JOHN DEERE GRASSLAND DRILL**

IT'S been said that the most important single factor in preventing soil erosion is the production and maintenance of a complete vegetative cover for the soil. A good cover crop breaks the force of rainfall and ties the soil together with a binding network of roots. Loss of topsoil from splash and runoff is cut to a minimum.

Your own best bet for producing a good cover crop is the new John Deere Model "GL" Grassland Drill. With the Grassland Drill, you can deep-place fertilizer while seeding small grains,

grasses, and legumes at their recommended depths in a band directly over the fertilizer. You get your cover established early—give your soil the protection it needs, when it's needed.

Of course, the Model "GL" is an all-around grassland drill that will mean better pasture and hay crops, too—enabling you to seed supplementary grazing crops in established sod. Get complete information from your John Deere dealer, or write for folder.



JOHN DEERE • MOLINE, ILLINOIS

# FOR REMOTE CONTROL JOBS on a great variety of AGRICULTURAL EQUIPMENT TRU-LAY Flexible PUSH-PULLS

are Dependable and Accurate even under the most adverse conditions. They perform effectively under extremes of Heat or Cold... from jet engine temperatures to 70° below zero F. The inner, working member (lubricated for life during assembly) is fully protected by the tough, flexible conduit. Abrasive dusts, dirt and moisture are sealed out. Fittings are cold swaged to make them integral parts of the control unit. It is a matter of record that we have never heard of a TRU-LAY flexible PUSH-PULL wearing out in normal service. Use of these versatile, simple and rugged controls means the virtual Elimination of Maintenance.

## Widely Used on Agricultural Equipment

Adaptability to all sorts of mechanical situations explains, in large measure, the wide-spread use of TRU-LAY PUSH-PULLS on Tractors and their accessories, Combines, Corn Pickers, Detasslers, and Row Sprayers, Orchard Sprayers, Tobacco Picking Machines, Power-driven Tree Trimmers and others.

On Agricultural Equipment these dependable Push-Pulls are used for the remote control of Transmissions,

Hydraulic and Air Valves, Brakes, Clutches, Throttles, Chokes, Governors, Power Take-Offs, Spray Nozzles, Vent Directional Fins, etc.

TRU-LAY PUSH-PULLS are precision products, not gadgets. They provide positive remote-action whether anchorages are fixed or movable... for light loads or loads up to 1,000 lbs... and they are effective over short or long distances, up to 150 feet or more.

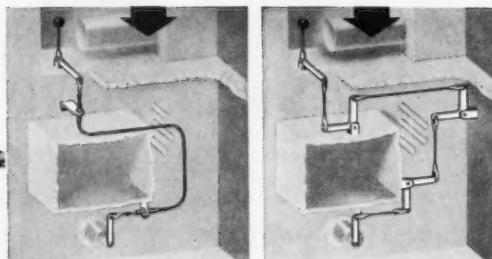
## Advantages of Tru-Lay Push-Pull flexibility and simplicity are pictured below

### TRU-LAY PUSH-PULL

Simple • One Moving Part  
Life-Time Service • Life-Time Accuracy • Low over-all Cost  
Noiseless

### MECHANICAL LINKAGES

Complex • Many Parts  
Many Points of Wear • Increasing Back-Lash • Loss of Accuracy • Vibration Rattles



**"Solid as a rod but flexible as a wire rope"** is a good description of TRU-LAY PUSH-PULL REMOTE CONTROLS. This flexibility makes it possible to snake around obstructions as shown in the picture at the left... permits the ideal arrangement of all control elements... greatly simplifies installation of controls by reducing the number of working parts... damps out noise and vibration. Versatile, Accurate, Adaptable, Rugged... they are the ideal Remote Controls for Agricultural Equipment.

Our DATA FILE will answer your further questions  
Write for a copy without obligation

**ACCO**



AUTOMOTIVE and AIRCRAFT DIVISION  
AMERICAN CHAIN & CABLE

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2216-B S. Garfield Ave., Los Angeles 22 • 929-B Connecticut Ave., Bridgeport 2, Conn.

## Users Report Important Savings, Improved Design and Better Appearance with TRU-LAY Push-Pulls

Here are typical benefits reported by users of these accurate and dependable Remote Controls.

### Governor

"For several models of farm tractors, we selected your controls for their simplicity and neatness of application as governor controls."

### Transmissions— Clutches—Brakes

"Greater flexibility of design. For remote control of transmissions, clutches and brakes these Flexible Push-Pulls can be installed where straight rods are impossible."

### Power Take-Off— Brake—Clutch

"Easier and less expensive to install than linkages for remote control of power take-off, brake and clutch. Better appearance, too."

### Hydraulic Control Valve

"The principal advantage in the use of the Tru-Lay cables in our application is that of permitting a more flexible location of the control valve in relation to the operator's position."

### Engines—Conveyors

"The use of your Flexible Push-Pulls saves us a great deal of time, labor and material. The old linkages frequently required much planning in both engineering and shop which is not required now. On some of our equipment we use Push-Pulls from 10 to 30 feet in length. They operate clutch controls on the Main Power Unit, Feed Conveyors and Delivery Conveyors."

### Wide Range of Application

**Adaptability** to all sorts of mechanical situations explains, in large measure, the widespread application of TRU-LAY PUSH-PULLS. Standard anchorages, fittings and heads have been designed that meet requirements on approximately 80% of the installations. Simple modifications of these standards, or minor changes in your own design, cover almost every special situation. Our engineers have the know-how on such matters. The DATA FILE pictured at the left contains six booklets and bulletins that will answer any further questions you may have about this versatile and dependable tool. It is quite likely that this material will point the way to a simplified solution of your remote control design problems. Write for a copy.



Caterpillar Diesel D6 Tractor at work in beet field. Caterpillar Diesel Tractors use oil filters and refills made by Purolator to Caterpillar's rigid specifications.

# PUROLATOR stands for

## Longer Engine Life . . . More Dependable Tractor Operation



With farm acreage up in all sections of the country, efficient tractor operation is, more than ever, an economic "must."

Today's farmer places so much dependence upon his tractor that at peak activity just a half day's "downtime" can virtually wipe out his profits.

To keep "downtime" to a minimum, tractor makers today give top attention to efficient oil filtration, a vital key to dependable, long-lived engine operation.

### 5 reasons why more tractor manufacturers specify Purolator-built filters and refills than any other make

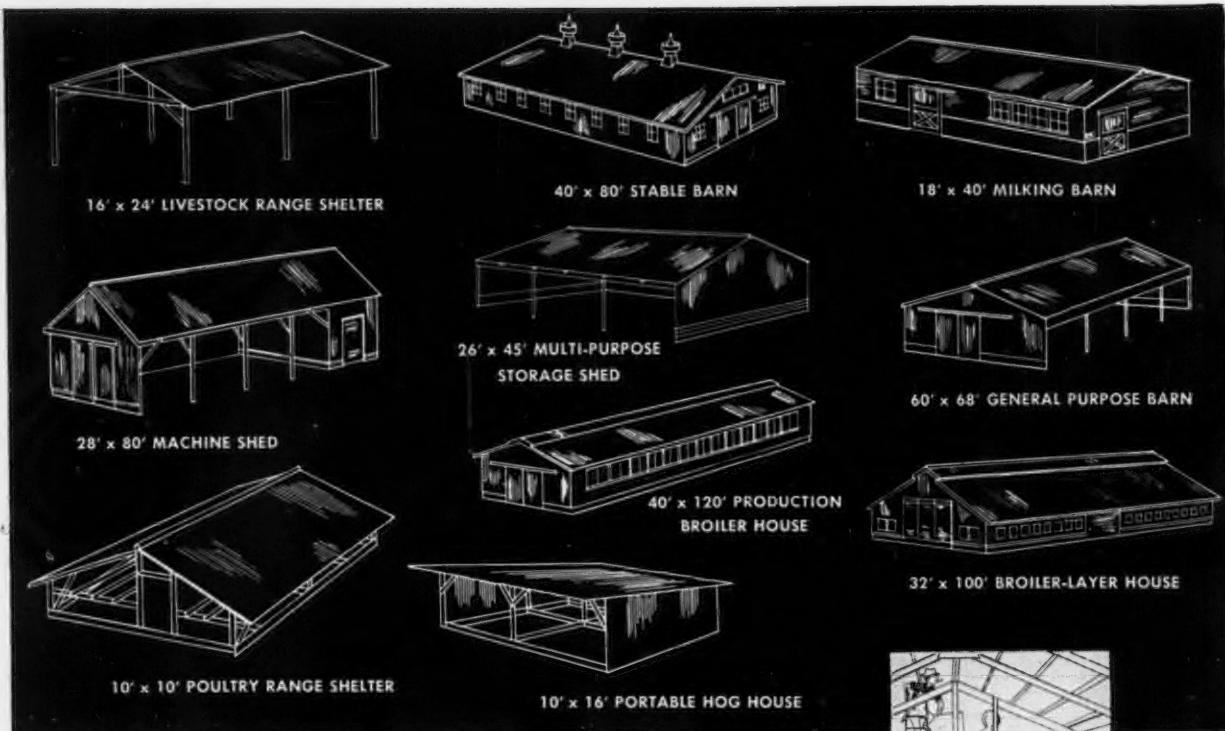
1. Purolator's famous "accordion-pleated" Micronic filter element has up to ten times more filtering area than ordinary types.
2. Electron micrographs prove that Purolator Micronic filters stop particles down to submicrons—.0000039 in.
3. The pleated design of the Purolator Micronic filter element provides many times more dirt storage space than old-style filters.
4. With its larger filtering area, the Purolator Micronic filter element introduces a remarkably small pressure drop into the lubricating system . . . permitting pumps of practical size and simple type.
5. With Purolator Micronic filtration, the tractor operator keeps all the oil quality he pays for. The Micronic filter element will not strip additives . . . an important advantage with HD and heat-resistant oils.

For further information write, wire or phone:  
PUROLATOR PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada.  
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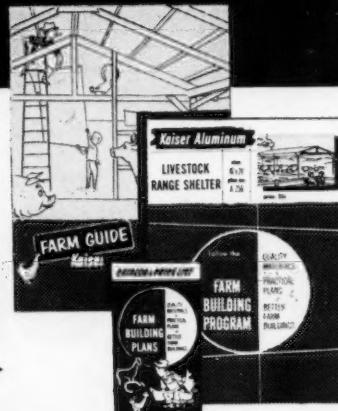
"Purolator," "Micronic," Reg. U. S. Pat. Off.





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Farm Building Plan Service  
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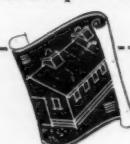
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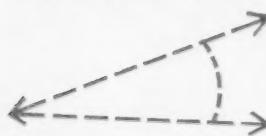
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INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N.Y.



## NEW BOOKS

**Machines of Plenty**, pioneering in American Agriculture, by Stewart H. Holbrook. Cloth, 246 pages, 5½ x 8½ inches. Illustrated and indexed. The Macmillan Co., 60 Fifth Ave., New York 11, N.Y. \$4.00.

The author captures the charm and warmth of American rural life with full regard to human struggles as he unfolds the development of agriculture from the days of the western migration of the early 1800's to the degree of mechanization enjoyed by farmers today. He recounts the role of such pioneers as Jerome I. Case, who contributed so much to the gradual mechanization of American farming.

Fred A. Wirt, advertising manager, J. I. Case Co., has described the book so aptly, by saying, "Seldom, if ever, has a single volume been so fascinating as biography, so faithful as history, and so penetrating in its appraisals . . ."

**Farm Service Buildings**, by Harold E. Gray. Cloth, vii + 458 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N.Y. \$7.50.

The principal objective of the book is to serve as a text for students of a general course in farm structures. It should be helpful also as a reference for teachers of vocational agriculture and is valuable as a guide for builders and farmers.

The book is divided into seven parts. The topics of each part are as follows: development and planning of farm buildings; materials of construction; structural requirements; environmental control; buildings for housing livestock; storage buildings; and remodeling farm buildings.

**Elements of Hydraulic Engineering** by R. K. Linsley, Jr. and J. B. Franzini. Cloth, xiii + 582 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y. \$9.00.

The new book is included in a series of books on civil engineering and is written as a basic textbook for senior civil engineering students. The text stresses the fundamentals of hydraulic engineering as a follow-up on material presented in a conventional first course in fluid mechanics.

Part I deals with the hydrologic and legal aspects which are common to almost all hydraulic projects. Part II discusses structures and reviews the elements of engineering economy. Part III discusses the special problems encountered in water supply and sewerage, flood control, drainage, irrigation, river navigation, hydroelectric power development and multiple-purpose projects. There are 215 problems for student solution.

**Dictionary of Mechanical Engineering Terms** revised by Staton Abbey (seventh edition). Cloth, iv + 417 pages, 5 x 7½ inches. Philosophical Library, Inc., 15 E. 40th St., New York 16, N.Y. \$6.50.

This dictionary might be described as a condensed encyclopedia and is prepared in two parts. The first part, entitled "Dictionary of Modern Terms", is made up of engineering terms that have come into use during recent years. Part II, entitled "Dictionary of General and Traditional Terms", although having been revised, contains the older engineering terms, which are in danger of dying out in present and future days of mechanized production. These older terms are being retained to maintain links with traditional craftsmanship.

(Continued on page 694)

# Driverless Tractors Save Labor

How one man can operate a combine . . . and drive a "Cat" by remote controls

"During the harvest season, we always had to hire extra help and sometimes the 'cat' drivers were inexperienced and drove too fast or too slow for the proper operation of our combines," says Lou Sheffels, 4,400-acre wheat farmer of Wilbur, Washington.

"After experimenting ten years with several driverless devices, my son and I worked out a system of cable controls two years ago. It gives complete control of the 'cat'—clutch, throttle, steering, brakes, gear shift and reverse without a driver being in the seat. He is in the combine.

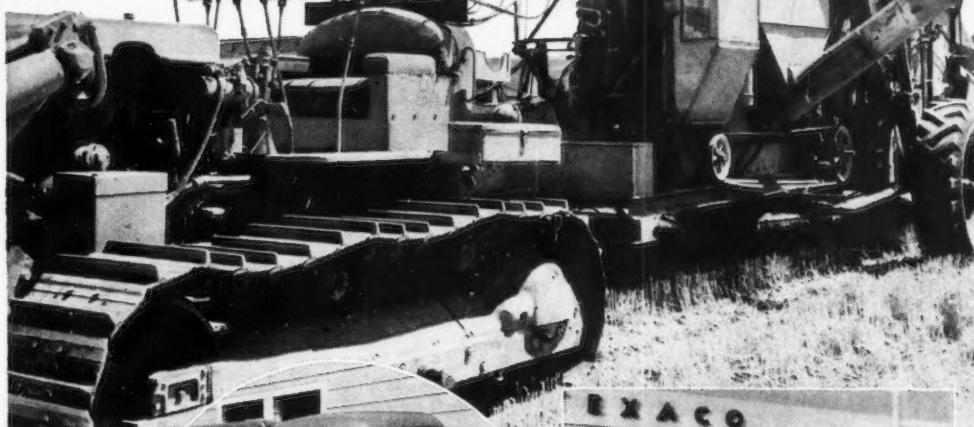
"There are six control levers to handle the 'cat' and six more

for the operation of the combine. The operator is happy to have full control of both outfits. The controls are so easy to operate you might say they are finger tip. These controls have eliminated the 'cat' driver, and each operator is doing a better job than was done by two men before.

"The controls were built in our own shop at a material cost of less than \$75."

It is significant that outstanding farmers, like Mr. Sheffels, find that *it pays to farm with Texaco products.*

Driverless tractor in operation: With 4,400 acres of wheat to harvest, Mr. Sheffels can't take chances. His equipment has to be right. And his lubricants must seal out grit and dirt, stick to the job in the field and not melt down, drip out, or dry out and cake up. That is why he uses Texaco Marfak. It stays on the job longer.



Arnold Danzer (left) has developed a number of "labor savers" including a novel dump wagon for his farm near Carroll, Iowa. Mr. Danzer finds it pays to use the best motor oil money can buy—Advanced Custom-Made Havoline. It out-performs them all. Popular Texaco Distributor Sam Hyland provides neighborly service.

Lou Sheffels (left) chats with Texaco Consignee J. G. Stephenson of Wilbur, Washington, who has just delivered Texaco Diesel Chief, the superior fuel for diesel motors, and a supply of Fire Chief, the gasoline with extra "Fire-Power" for low-cost operation in gasoline engines.

## ★ In Town or on the Highway —

there is a nearby Texaco Dealer. He has new top octane Sky Chief gasoline, supercharged with Petrox, to give maximum power and reduce engine wear . . . famous Fire Chief, at regular gasoline prices, both 100 per cent *Climate-Controlled* . . . Advanced Custom-Made Havoline Motor Oil and Marfak lubricant.



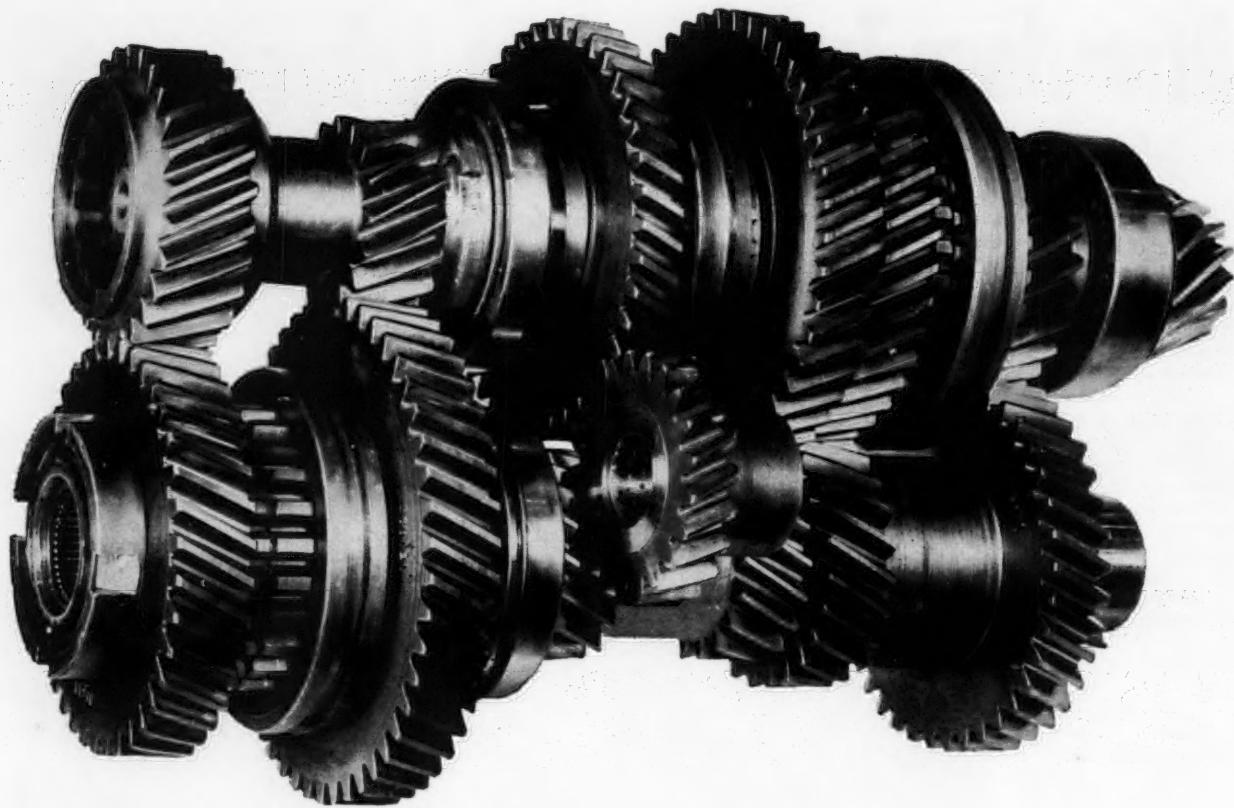
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ON FARM AND HIGHWAY  
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**Oliver provides extra stamina** where it counts in gears and shafts, by using nickel alloyed steels of the 8600 series. Oliver Corporation uses 8620 type steel for gears and shafts of this tractor

transmission, and for differential ring gears, bevel pinions and shafts. Studs and bolts, throughout the tractor, are 8630 type steel. Inlet valves are type 8640 quenched and tempered.

## Where a little nickel is the farmer's best friend

Twist, jerk, overload gear teeth...smack them with sudden shocks, high pressures, brutal stresses . . .

Where use means abuse, you'll find that gears can "take it" if they're fortified with nickel.

Because nickel imparts strength, and increases hardness without sacrificing toughness. Nickel tends to widen the safe heat treating range, reduce distortion and improve effects of other alloy elements.

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Steel for any particular part must, obviously, have mechanical properties to answer service demands. And it should also readily respond to fabrication. From the many standard grades of nickel alloy steels available, you can usually choose exactly the right one to meet your particular demands. If you have a metal difficulty, let us help you. Write for List A of available publications. It includes a simple form that makes it easy for you to outline your problem.

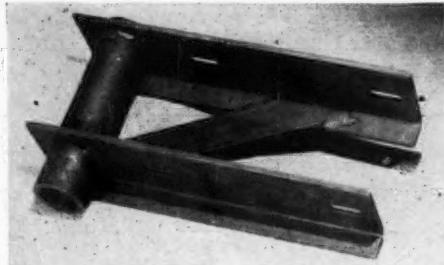


**THE INTERNATIONAL NICKEL COMPANY, INC.**

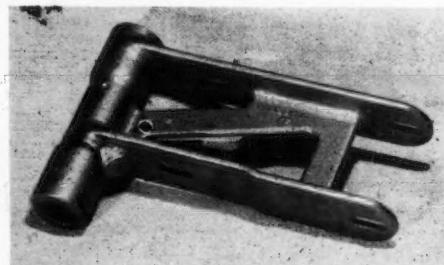
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cut cost 52%**



A fan drive bearing housing, fabricated as a weldment, used four pieces of steel. Two of these pieces required bending and punching before assembly. Cost was high, dimensions varied and appearance was not good.



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*Your inquiries are invited.*

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# ADVANTAGES OF FLEXIBLE SHAFTING for Power Drive and Remote Control

by C. HOTCHKISS, JR.  
*Application Engineer,*  
Stow Manufacturing Company

Flexible shafting has the following advantages over other type drives:

- 1 — It is often the simplest method of transmitting power between two points which are not collinear or which have relative motion
- 2 — eliminates exposed revolving parts
- 3 — does not require accurate alignment
- 4 — easy to install and maintain.

**NOT COLLINEAR** — Where it is necessary to connect two shafts which are not collinear, a simple arrangement of a single belt or two universal joints will often do the job adequately. But, in many cases where the path of transmission is more complicated and would require a more expensive arrangement of mechanical components, flexible shafting provides a simple, low cost, efficient drive which is easy to install because it does not require accurate alignment. See example, figure 1, in which a  $\frac{1}{4}$ -inch Stow flexible shaft is used to drive the auger on a G.L.F. bulk feed truck.

Flexible shafting also allows the designer greater freedom in locating either the drive or the driven component on a piece of equipment.



Fig. 1

**STOW MANUFACTURING COMPANY**  
39 SHEAR STREET • BINGHAMTON, NEW YORK

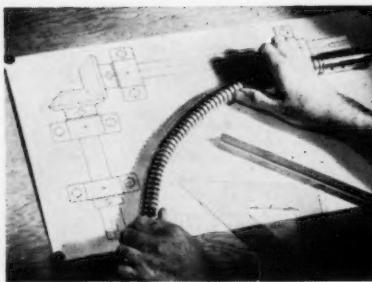


Fig. 2

**RELATIVE MOTION** — Where two shafts which have relative motion must be connected, flexible shafting is often the ideal means of transmission. In many cases it eliminates a much more complicated drive which would, necessarily, include telescopic joints; further, it eliminates the danger of exposed moving parts. See figure 2, which shows a  $\frac{3}{4}$ -inch Stow flexible shaft driving an Avery Rake built by the Minneapolis Moline Co.



Other typical applications of this type are used on portable power tools when motors are too heavy to be mounted on the tool—such as portable grinders, sanders, paint scrapers, saws and tree tappers. And, since flexible shafting is not affected by vibration, it is an ideal drive for applications where a high degree of vibration is involved—such as in vibration testing tables and concrete vibrators.

Stow flexible shafts are available for power drive applications in diameter sizes from  $\frac{1}{8}$  inch to  $\frac{1}{4}$  inches; for remote control applications in diameter sizes from  $\frac{1}{8}$  inch to  $\frac{1}{2}$  inches.

The  $\frac{1}{4}$  inch power drive shaft will transmit up to 10 HP while the  $\frac{1}{2}$  inch remote control shaft will transmit up to 4000 lb. in.

For complete engineering data on flexible shafting, including selection charts, write for engineering bulletin 525.

## NEW BOOKS

(Continued from page 690)

**Handbook of Engineering Materials**, by D. F. Miner and J. B. Seastone. (First edition). Cloth, xi + 1382 pages,  $5\frac{1}{2} \times 8\frac{1}{2}$  inches. Illustrated and indexed. John Wiley and Sons, 440 Fourth Ave., New York 16, N. Y. \$17.50.

The handbook provides a source of information on the materials of manufacturing and construction in all branches of engineering. The handbook has been arranged by classes of related or similar materials. The first section covers general information on materials with specifications and standards. The section on metals includes ferrous metals, aluminum, magnesium, copper and its alloys, zinc, nickel and its alloys, other pure metals, and special-purpose metals and alloys. The third section is on non-metals and covers wood and wood-base materials, paper, fibers, plastics, rubbers, organic finishing materials, fuels, carbon products, ceramic materials, industrial chemicals and lubricants. Construction materials such as cementing materials and concrete, roadbed materials, timber, rope, foundations, weather and moisture protection, and glass products are included in the fourth and final section.

**Industrial Lubrication Practice**, by Paul D. Hobson. Cloth, x + 549 pages,  $6 \times 9$  inches. Illustrated and indexed. The Industrial Press, 93 Worth St., New York 13, N. Y. \$8.00.

This book was written as a guide to sound lubricating practice. It provides valuable information to engineers who are responsible for lubrication applications. The emphasis throughout is on lubrication practice; lubrication theory is touched on only when necessary to point out reasons for techniques and phenomena.

Chapters include principles of lubrication; running in new bearings; types of lubricants and their use; characteristics of lubricants; methods of lubricant supply; plain bearings; anti-friction bearings; organization of a lubrication department; storage and handling of lubricants; purification and reclamation of oil; hydraulic systems and equipment; electric motors and generators; two and four-stroke gasoline engines; diesel engines; compressors; refrigeration equipment; pneumatic tools; reciprocating steam engines; steam turbines; metal forming and cutting machines; cutting fluids; gears, chains, ropes, belts and couplings; and storage preservation of machinery.

**Farmstead Wiring Handbook**, by Industry Committee on Interior Wiring Design (second edition). Paper, 48 pages,  $8\frac{1}{2} \times 11$  inches. Illustrated with complete table of contents. Published by Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y., 50 cents (quantity prices on request).

This is a book on how to plan wiring and not a book on how to install wiring. It contains recommendations and suggestions on such things as sizes of wire, number and location of outlets to help the farmer in his wiring needs. The handbook is divided into three sections: Interior wiring design, outdoor electric distribution, and a series of tables which show wire sizes needed to carry various electrical loads.

Material was developed by experts from 12 sponsoring and endorsing organizations. These organizations include the American Society of Agricultural Engineers. Copies are available by writing: Industry Committee on Interior Wiring Design, Room 2650, 420 Lexington Ave., New York 17, N. Y.



## OLIVER PRESENTS THE SUPER 88

### Today's most powerful Row Crop Tractor

Now more powerful than any other row crop tractor, the Super 88 has 49.81 max. h.p. on the drawbar.

It pulls bigger implements, handles heavier loads under tougher conditions and comes through with flying colors every time.

Tops in economy, too, the Super 88 set the record in recent nationally recognized tests. It has a new high in compression ratios—7.0:1—to squeeze extra power from every drop of fuel. Offers your choice of

gasoline or diesel engine, whichever costs less to run.

"Hydra-lectric" control system raises and lowers implements and regulates depths at the touch of a lever. The Super 88 has the widest range of speeds in farming: five working speeds, plus one road speed, plus two reverse . . . and it has Oliver's famed Independently Controlled PTO.

Best news of all, the Super 88 makes all these advancements in

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The new 88 is one of the Oliver Super tractors—models 55, 66, 77, 88 and 99—developed to offer a standout value in each of five power classes.

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# Unitcast



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### Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

**Batchelder, David G.** — Agricultural engineer, Oklahoma A. & M. College, Stillwater, Okla. (Mail) 802 S. Monroe

**Clark, David F.** — Field representative, Rainway Div., Shannon Tractor & Pump Co. (Mail) RR 1, Box 160, Winton, Calif.

**Denis, Elmer C.** — Manager, applied research dept., Doane Agricultural Service, Inc., 5144 Delmar Blvd., St. Louis 8, Mo.

**DuShane, W. H.** — Project engineer, John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 2310 Ansborough Ave.

**Ellison, Oliver T.** — Area engineer (SCS), USDA. (Mail) Box 343, Fort Peck, Mont.

**Hauge, Allen D.** — Drainage engineer, Rockford Brick and Tile Co. (Mail) Rockford, Iowa

**Head, Glenn D. Jr.** — Junior engineer, John Deere Des Moines Works, Des Moines, Iowa. (Mail) 1104 E. Douglas

**Holland, Joe M. Jr.** — Operating and technical dept., Spencer Chemical Co. (Mail) 2945 10th St., Port Arthur, Tex.

**Howard, Audrey L.** — Structural design engineer and partner, Resort Technical Services. (Mail) 1106 W. Jackson, Borger, Tex.

**Howard, Roy J.** — Plant engineer, Charles M. Cox Co. (Mail) 48 Nashua St., Woburn, Mass.

**Hurlburt, Richard W.** — Irrigation division head, Tractor Sales Corp. (Mail) 4066 Hill St., Huntington Park, Calif.

**Johnson, Bernard D.** — Agricultural engineer, Pacific Gas & Electric Co., 245 Market St., San Francisco 6, Calif.

**Johnston, Thomas J.** — Agricultural engineer, Mississippi Agricultural Extension Service. (Mail) Stoneville, Miss.

**Kilbourn, Burwell N.** — Chief engineer, Dempster Mill Mfg. Co., Beatrice, Nebr.

**King, Harvey H.** — Agricultural engineer (SCS), USDA. (Mail) Box 951, Angleton, Tex.

**Larson, Jerrel J.** — Student engineer, John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) RR 1, Box 158

**Larson, Kenneth L.** — Sales trainee John Deere Plow Co. (Mail) RR 2, Box 60, Lindsborg, Kans.

**Lockwood, F. St. John Jr.** — Western regional sales manager, Tractor & Implement Div., Ford Motor Co. (Mail) 1508 Financial Center Bldg., Oakland 12, Calif.

**Lowry, Jr. Claude** — Agricultural engineer (SCS), USDA. (Mail) 106 N. Lewis St., Pickens, S. C.

**McLeroy, Benjamin B.** — 2nd Lt., USAF. (Mail) OMS Box 957, Class 56-F, Laredo AFB, Tex.

**Mills, Clifton E.** — Manager of seed stocks, John F. McNair, Inc., Laurinburg, N. C. (Mail) Box 706

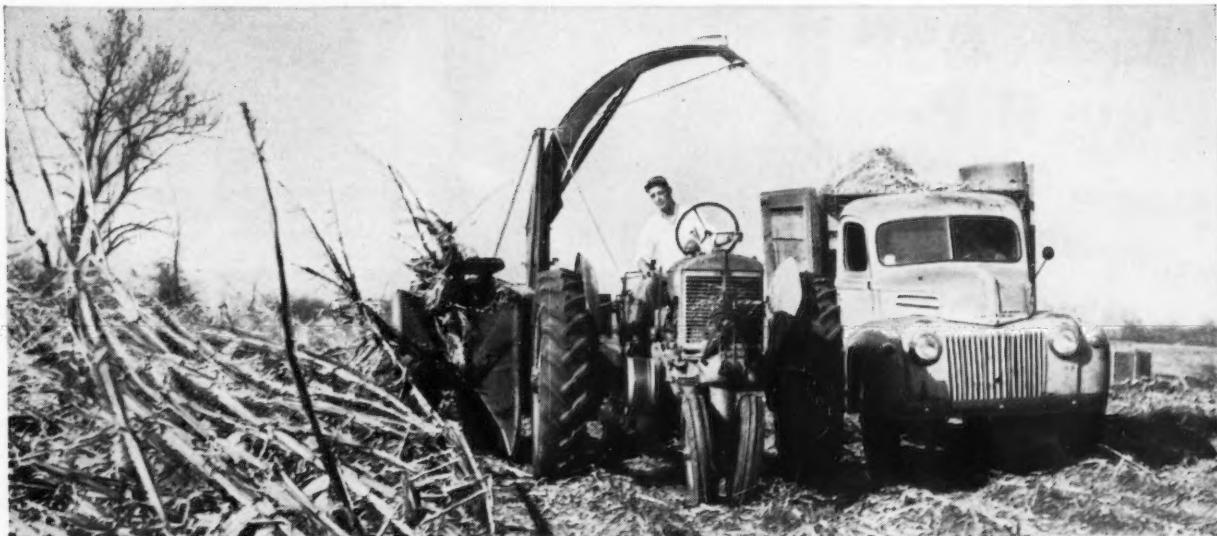
**Moe, Orlean R.** — Trainee, Hawaiian Sugar Planter's Assn., 1527 Keeaumoku St., Experiment Station HSPA, Honolulu 14, Hawaii

**Moore, Thomas A.** — Agricultural engineer (SCS), USDA. (Mail) 920 Cherry St., Forrest City, Ark.

*(Continued on page 698)*



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There's no need for special down-corn attachments because New Holland's corn head with exclusive fender design and longer snouts sweeps up row crops in *any* condition . . . as much as 24 tons an hour.

Channel between the fenders is wide enough—30 inches between points—to take the heaviest stalks while gathering chain fingers extend enough to hold and carry thin short plants.

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Drink more milk  Eat more meat  
for a healthy America and a strong agriculture



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697

## Applicants for Membership

(Continued from page 696)

**Nachmany, Israel**—Lecturer in agricultural engineering, Technion—Israel Institute of Technology, PO Box 4910, Haifa, Israel  
**Nobles, Muriel E.**—Farm electrification adviser C & L Rural Electric Cooperative Corp., Star City, Ark. (Mail) Box 126  
**Pevey, Malcolm A. Jr.**—Sales engineer, Delta Irrigation Co. (Mail) 757 Maple Ave., Clarksdale, Miss.  
**Ralston, Elton R.**—2nd Lt., U.S. Marine Corps. (Mail) RFD Z, Box 69-B, Marion Jct., Ala.  
**Ramakrishnan, Cheyur R.**—Agricultural engineer and sales executive, Larsen & Toubro Limited, PO No. 5247, Madras 2, India

**Schoof, Russell R.**—2nd Lt., U.S. Army (Mail) 9470 Training Unit, Army Electronics Proving Grounds, Fort Huachuca, Ariz.  
**Schoof, William V.**—Graduate assistant in agricultural engineering, Kansas State College, Manhattan, Kans. (Mail) Apt. 101, 1615 Anderson Ave.  
**Shanklin, John H.**—Agricultural engineer (REA), USDA. (Mail) 5903 Aspen Ave., N.E., Albuquerque, N. M.  
**Shumshere, Rana K.**—Senior agricultural engineering assistant, U.S. Operations Mission, Rabi Bhawan, Kathmandu, Nepal  
**Timmins, Merrill S. Jr.**—Architect (AERB, ARS), USDA, Beltsville, Md.  
**Wijewardene, P. Rayatha**—Agricultural engineer and managing director of arable and plantation farms, 135 Turret Rd., Victoria Park, Colombo 7, Ceylon

**Woolhiser, David A.**—Research assistant in agricultural engineering, University of Arizona, Tucson, Ariz. (Mail) 2501 E. 5th St.

**Wright, James C.**—Service supervisor, International Harvester Co. (Mail) 37 Krotiak Rd., Park Forest, Ill.

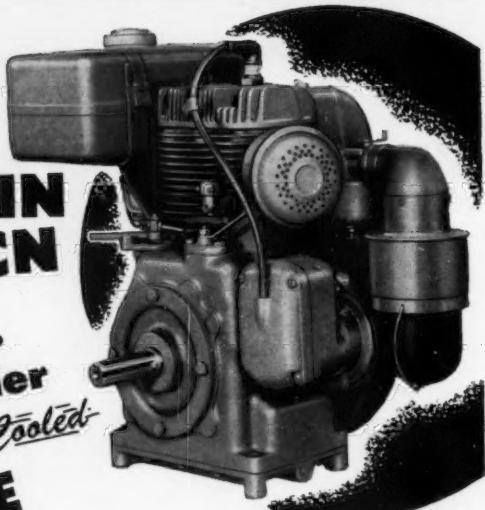
### Transfer of Membership Grade

**Gulvin, Harold E.**—Head, research div., farm supply dept., Eastern States Farmers Exchange, Inc. (Mail) 108 Edgewood Ave., Longmeadow, Mass. (Transfer from Affiliate)

**Patel, Shantibhai M.**—Postgraduate student in agricultural engineering, King's College, Newcastle-on-Tyne 2, U.K. (Affiliate to Associate Member)

**Shepard, Francis D.**—Rural service representative, Niagara-Mohawk Power Corp. (Mail) Box 14, West Rush, N.Y. (Affiliate to Associate Member)

**This is the NEW WISCONSIN Model ACN**  
**5½ H. P.**  
**Single Cylinder**  
**HEAVY-DUTY *Air-Cooled***  
**ENGINE**



Here is a new, light weight engine, designed and built to Wisconsin heavy-duty standards in all details, offering original equipment builders and engine users maximum power advantage and performance in a 2.3 to 5.6 hp. range at 1600 to 3600 rpm.

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MILWAUKEE 46, WISCONSIN

## NEW BULLETINS

**Automation—Engineering for Tomorrow** (sponsored by the school of engineering, Michigan State University), a 54-page booklet containing the addresses given at the Engineering Centennial Symposium, held May 13, 1955, at East Lansing. Contents include "Automation to Date," by Roger W. Bolz, editor, *Automation Magazine*; "Development of Automatic Production Facilities," by J. B. Cunningham, manufacturing specialist, Convair; "Automation as the Engineer Sees It," by W. R. G. Baker, vice-president, General Electric Co., and "Automation—A Look Into the Future," by Erie A. Walker, dean of engineering, Pennsylvania State University.

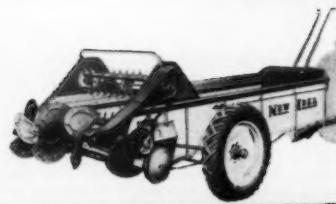
A mimeograph report of the high lights of the meeting held by the MSU agricultural engineering department as a contribution to the symposium, entitled "Agriculture—A New Field for Automation," is also available. The report contains notes from a talk on automatic handling of agricultural materials by S. S. DeForest, associate editor, *Successful Farming*, and from a panel consisting of H. J. Barre, consulting agricultural engineer; C. R. Olson, manager, Olson Management Service; A. R. Satullo, The Satullo Co., and S. S. DeForest.

**Research Summaries**, Department of Agricultural Engineering, Ontario Agricultural College, Guelph, (June, 1955). Illustrated. Projects summarized include the effect of tillage methods on crop yields and soil conditions, the effect of deep-tillage machinery on crop yields on Haldimand clay soil, methods of seeding and seedbed preparation, air-distribution tests in hay driers, basic drying experimentation, continuous-type hay drier, frostproof watering bowls, utilization of sheathing and roofing materials in portable hog houses, runoff from small agricultural watersheds, the use of infiltration determinations for runoff estimates, irrigation water supply survey, evapotranspiration requirements for potatoes, hydraulics of sand point batteries, and new projects.

**NIAE Bulletins**. The following bulletins have been received recently from the National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, England:

A Study of the Effect of Grass Cracking on the Drying Rate in the Swath and on Racks, and of the Disposal of Hay by Baling and Chopping in 1953—Report No. 48

(Continued on page 700)



The  
Guaranteed  
Spreader  
with the  
**Blue Ribbon**  
features

**SLANTED ARCH.** The heavy arch is out of the way for easier loading. Does not interfere with high spots on the load.

**BIGGER UPPER CYLINDER** further increases shredding efficiency. Strengthened with 3 inside support heads.

**STRONGER DISTRIBUTOR SHAFT** and bearings. Any paddle can be removed separately.

**HEAVY STEEL ENDGATE** ties the wood sides and bottom into one strong unit.

**"U" SHAPED HITCH** of heavy formed steel ties 'way back into main frame for added strength and heavier loads.

**PENTA-TREATED**, water repellent wood sides and bottom insure even longer rot-free life.

**STEEL FLARES** run full length of bed—give added protection when loading, and strengthen box.

**GUSSET PLATE** reinforcing from frame to box gives strongest New Idea box ever.

**EFFECTIVE SHIELDING**—all working parts protected by higher and wider shields.

**BIG 7.50-24 TIRES** give plenty of power; tires and wheels are interchangeable with New Idea pull type pickers.

# The New NEW IDEA No. 17 Spreader

## Outperforms 'em all!

This new 95 bushel capacity spreader is the finest in our 56 years of spreader building. It's the biggest and most efficient of all ground-driven spreaders. Strains of mechanical loading and high speed spreading are taken in stride. Every one of its many "Blue Ribbon" features listed at left spell quality. Its full year guarantee puts it in a class by itself. In fact, this spreader is by far the best spreader value available today.

**NEW IDEA FARM EQUIPMENT COMPANY**  
COLDWATER, OHIO, U. S. A. **AVCO**  
DIVISION DISTRIBUTING CORPORATION

**95 bu. capacity**



There are more NEW IDEA Spreaders in use than any other make.



No. 15 P.T.O.  
120 bu. capacity



No. 14-A  
65 bu. capacity



No. 10-A  
75 bu. capacity

## NEW BULLETINS

(Continued from page 698)

Summary of Work on Frost Prevention—Technical Memorandum No. 120.

Measurements with Strain Gages at the NIAE—Technical Memorandum No. 106.

Agricultural and Horticultural Engineering Abstracts, Vol. VI, 1955 No. 3—Abstracts from world literature.

Plot Spraying Equipment—Technical Memorandum No. 122. This bulletin describes the design and construction of boom-type spraying equipment for mounting on a land rover.

The Effect of Heating and Chilling as a Means of Overcoming Dormancy in Barley—Technical Memorandum No. 123.

Environmental Physiology and Shelter Engineering with Special Reference to Domestic Animals. Missouri Agricultural Experiment Station (Columbia), Research Bulletin 578, (February, 1955).

XXXIII. Milk Production, Feed and Water Consumption, and Body Weight of Jersey and Holstein Cows in Relation to Several Diurnal Temperature Rhythms, by Brody, Ragsdale, Yeck and Worstall. Lactating cows exposed to temperatures of 10 to 40 F diurnal rhythm showed no decline in milk production for Holsteins and a slight decline for Jerseys as compared with 40 to 70 F. During the first week of 70 to 100 F diurnal rhythm, milk production declined by about 20 percent in Holsteins and by about 8 percent in Jerseys.

## PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITION OPEN—APRIL—O-125-718, 173-721. MAY—O-180-724, 214-727, 214-728. JUNE—O-248-733. JULY—O-289-735, 307-739, 318-740. AUGUST—O-305-741, 319-742, 325-743, 324-745, 334-746, 338-747, 345-748, 346-749, 346-750, 347-751, 350-752. SEPTEMBER—O-331-754, 363-755, 335-756, 352-758, 372-759, 384-760.

POSITIONS WANTED—JUNE—W-203-25, 247-27, 252-29, 263-31. JULY—W-266-35. AUGUST W-312-40. SEPTEMBER—W-351-41, 369-42.

### NEW POSITIONS OPEN

PRODUCT TEST ENGINEERS (4 openings) for advanced test work with established broad line manufacturer in Midwest. Age 30-45. BS deg in agricultural or mechanical engineering. Farm background and 4 to 6 yr experience in the farm equipment field, including tractor or implement design. Mature, sound judgment on the function and performance of experimental farm equipment. Must be willing to travel and able to train and supervise younger, less experienced personnel. Good opportunity for advancement in expanding organization. Salary \$500-600 per month or more, depending on qualifications. O-401-761

EXTENSION AGRICULTURAL ENGINEER for service in Brazil with International Cooperation Administration, developing programs in farm mechanization, electrification, water systems, housing and farm buildings, farm processing, grain drying, and feed mixing. Age 35-50. BS deg in agricultural engineering. Must know extension methods and have extension or teaching experience. Job requires tact, imagination, creative ability, capacity to get along with all types of people and get them to work. Should be strong and able to travel, 50 percent field work. Opportunity depends on development of program and willingness to stay abroad. Salary \$8270 base plus allowances. O-402-762

AGRICULTURAL ENGINEERING ADVISOR for service in Nepal with International Cooperation Administration, advising on improvement of farm equipment, training local craftsmen, development of small irrigation projects, use and selection of equipment and preparation and distribution of agricultural information. Age under 50. Some irrigation experience required. Must be rugged, emotionally well adjusted, pioneering type, adaptable to entirely new environment, and able to "make do" and improve. Excellent opportunity for advancement if impression is made on the problem. Salary \$7630 plus 25 percent differential and allowances. O-402-763

IRRIGATION ENGINEER to plan and execute an active portable irrigation program with large eastern truck crop producer and processor. Age 25-35. BS deg in agricultural engineering, preferably with major in soil and water field. Farm background preferred. Prior experience with portable irrigation equipment necessary. Requires initiative, imagination and ability to cooperate and get along well with others. Excellent opportunity for advancement. Salary open. O-404-764

DESIGN AND DEVELOPMENT ENGINEER for power choring equipment with established manufacturer in Midwest. Age 25-36. BS deg in agricultural or mechanical engineering. Minimum of 3 years in design and development work. Able to get along and work cooperatively with others. Excellent opportunity with nationally known producer having continued growth possibilities. Location close to good hunting and fishing. Salary open. O-405-765

SALES TRAINEES, export and domestic, with internationally known manufacturer of tractors and heavy equipment. Various assignments following extensive training program. Age 21-35. BS deg in agricultural engineering. Some experience with heavy earth moving equipment helpful. Intelligence, good health, and a desire to work with people. Opportunity for personal growth and development with growing world-wide organization having products which enjoy excellent reputation. Salary open. O-409-766

RESEARCH ENGINEER for work on heavy equipment with internationally known manufac-

(Continued on page 702)

**ELECTRIC**

# Wheels Engineered for the Job

WRITE US FOR RECOMMENDATIONS



**ELECTRIC WHEEL COMPANY**  
2802 SPRUCE • QUINCY, ILLINOIS

"I shot an arrow into the air,  
It fell to earth, I know not where."

*The Arrow and the Song—Longfellow, 1845*

# Longfellow a space buyer?

Longfellow's lament could well have been applied to advertising back in 1845. Yes, even up to 1914 when a group of advertisers, agencies and publishers, alarmed by the waste and guesswork in their business, brought order out of advertising chaos by organizing the Audit Bureau of Circulations. These pioneers in circulation auditing established a definition for paid circulation, rules and standards for measuring circulation, methods for auditing and reporting the FACTS.

*For value-minded advertisers the era of blind space buying ended in 1914. ☆☆*

Today's experienced space buyers use the audited information in A.B.C. reports to aid them in applying media to markets and get full value for advertising dollars. Here are some of the FACTS in

A.B.C. reports that provide a sound basis for advertising investments:

- How much paid circulation • How much unpaid distribution • Occupational or business breakdown of subscribers • Where they are located • How much subscribers pay • Whether or not premiums are used
- How many subscribers in arrears • What percentage of subscribers renew. ☆☆ Sales messages go direct to their targets, there's no shooting "into the air" when space buyers base their decisions on A.B.C. FACTS. This publication is a member of the Audit Bureau of Circulations because we want our advertisers to know what they get for their money when they use space in these pages. Ask for a copy of our A.B.C. report and then study it.



## SEND THE RIGHT MESSAGE TO THE RIGHT PEOPLE

Paid subscriptions and renewals, as defined by A.B.C. standards, indicate an audience that has responded to a publication's editorial appeal. With the interests of readers thus identified, it becomes possible to reach specialized groups effectively with specialized advertising appeals.

## AGRICULTURAL ENGINEERING

A.B.C. REPORTS—FACTS AS A BASIC MEASURE OF ADVERTISING VALUE

## Personnel Service Bulletin

(Continued from page 700)

turer. Midwest location. Age 22-32. BS deg in agricultural engineering. Intelligence, good health, and inherent desire to work in the field of research and development. Opportunity for personal growth and development with growing world wide organization manufacturing products which enjoy an excellent reputation. Salary open. O-404-767

DESIGNERS (2) for work on various phases of engine and equipment design with internationally known manufacturer. Midwest location. Age up to 50. BS deg in engineering or equivalent. Experience in machine design and development. Some manufacturing experience would be helpful. Intelligent, with good health, ability to work with people, mechanical aptitude and knowledge of engineering principles. Opportunity for personal growth and development with growing world-wide manufacturer of products which enjoy an excellent reputation. Salary open. O-409-768

TERRITORY MANAGERS (6 or more) to service established dealer accounts and sell full-line franchise to new dealers. Open territory in various areas. Prefer older men with proven ability in selling farm equipment. Usual per-

sonal qualifications for farm equipment sales and related management. Excellent opportunity in expanding organization for advancement in branch sales organization. Pension plan and usual employee benefits. Replies and interviews confidential. Salary open. Bonus arrangement. O-407-769

ASSISTANT TO SALES MANAGER, to direct sales organization and program of expanding farm equipment manufacturer. Prefer mature man with several years successful experience in sales and direction of farm equipment sales work. Energetic, willing to work hard. Usual personality qualifications for sales work. Excellent opportunity for man qualified for division sales manager. Replies and interviews confidential. Salary open. O-407-770

ASSISTANT TO GENERAL MANAGER for expanding farm equipment production and sales organization. Require mature man with well-rounded experience in advertising, sales, research, design, and manufacturing in farm equipment field. Usual personal qualifications for success as general manager of manufacturing and sales organization. Excellent opportunity for advancement on retirement of present general manager. Replies and interviews confidential. Salary open. O-407-771

AGRICULTURAL ENGINEER, professor or associate professor rating, to head power and machinery research and teaching in agricul-

tural engineering department at an eastern state university, including teaching of advanced undergraduate and graduate courses. Age 35-45. MS deg or higher in agricultural engineering, or equivalent. Usual personal qualifications for university work. Teaching and research experience in a college agricultural engineering department, and preferably some industrial experience. Early appointment desired for opening to be filled July 1, 1956. Salary open. O-413-772

AGRICULTURAL ENGINEERS (several) for beginning engineer work on design and development of agricultural sprayers for orchards, row crops, and weed control, with eastern manufacturer. Recent graduate with BS deg in agricultural engineering, or equivalent, and two years or less experience. Usual personal qualifications for engineering in manufacturing industry. Excellent opportunity for advancement in firmly established company concentrating on agricultural sprayer field. Personal interviews with likely prospects following review of personal data. Salary open. O-415-773

AGRICULTURAL ENGINEER for field investigations, educational work, system design and other assistance to chief engineer of established western manufacturer of sprinkler irrigation equipment. Considerable travel required. Age, under 40. BS deg in engineering, preferably agricultural. Sprinkler irrigation design experience required. Must be able to address meetings and get along well with people. Good opportunity for advancement. Salary open. O-394-774

### NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for extension, research, sales, or farm management in power and machinery or soil and water field with college experiment station or farming operation in West or Northeast. Married. Age 29. No disability. BS deg in agricultural engineering, 1949, Oklahoma A & M College. Farm background. Sales trainee one year. Manager of multiple franchise farm machinery dealership 4 yr; sales and application engineer for irrigation equipment distributor one year. War commissioned service in Air Corps, nearly 3 yr. Available on reasonable notice. Salary open. W-383-43

AGRICULTURAL ENGINEER for design, development, research, extension, teaching, or writing in farm structures or soil and water field with industry or public service, anywhere in USA or in Latin America or Europe. Limited travel. Married. Age 27. No disability. BS deg in civil engineering and in agricultural engineering, 1952, University of Maryland. Some experience on general and beef cattle farms. With public works department of large naval research establishment 3 yr, preparing plans, cost estimates, and specifications for alterations and additions to existing buildings and facilities. Also some surveying and coordinating of construction. Available now. Salary \$5600. W-391-44

AGRICULTURAL ENGINEER for design, development, or research in soil and water field with manufacturer or consultant, anywhere in USA. Limited travel. Married. Age 27. No disability. BS deg in agricultural engineering, 1950, Kansas State College. Summer employee 8 yr on diversified farm in Iowa. Sales engineer one year with distributor of marine boiler chemicals servicing ships of US Lines. Agricultural engineer with SCS, GS-5 one year; GS-7 work unit conservationist 2 yr; GS-9, flood control engineer, over one year. Available on 4 weeks notice. Salary \$5600. W-398-45

AGRICULTURAL ENGINEER for full time extension, teaching or research in soil and water field with federal agency, college or experiment station, in Midwest or West, with opportunity to work toward PhD. Married. Age 28. No disability. BS deg 1952, MS deg 1953, in agricultural engineering, University of Illinois. Farm background. Research and teaching assistant one year half time. Nearing completion of extended active duty tour in US Naval Reserve as electronics officer on a destroyer. Available Jan. 1, 1956. Salary open. W-388-46

AGRICULTURAL ENGINEER for extension, teaching or research in rural electric or soil and water field with public service in Southeast or South. Will consider other locations and types of employment. Married. Age 37. No disability. BS deg in agricultural engineering, 1950, Clemson College. Irrigation sales engineer 1 1/2 yr; electrification advisor with electric cooperative 3 1/4 yr. War enlisted service in Army 3 yr. Available now. Salary open. W-375-47

AGRICULTURAL ENGINEER for design or development in power and machinery field with manufacturer in Midwest or South. Married. Age 39. No disability. BS deg in agricultural engineering, 1941, Kansas State College. Farm background. Set up and serviced farm machinery 5 summers prior to graduation. Tool and die maker 4 yr in small arms plant. Design of spraying and dusting equipment 7 1/2 yr. Present position chief engineer. Available on 30-60 days notice. Salary open. W-420-48



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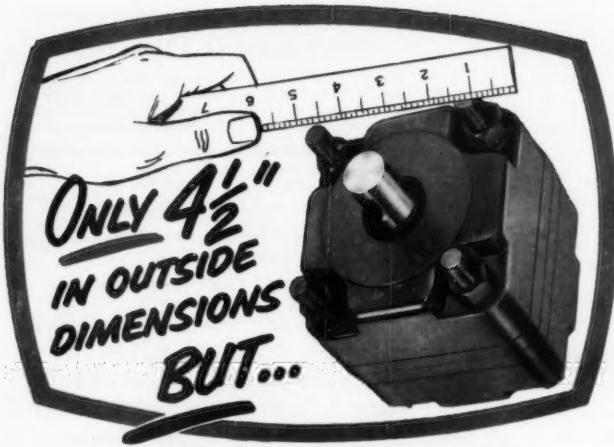


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**400 PUMP**

**UP TO 1500 P.S.I.**  
**UP TO 2100 R.P.M.**

This hydraulic pump is REVERSIBLE WITHOUT ALTERATION. The  $\frac{1}{8}$ " dia. shaft (with  $\frac{3}{16}$ " key) is housed in Anti-Friction bearings. The hardened steel precision gears (GEROTOR TYPE) are enclosed within an alloyed Die Cast Aluminum body. Mounting is directly on studs which can be reversed for mounting off back of pump.  $\frac{3}{4}$ " N.P.T. oil ports.

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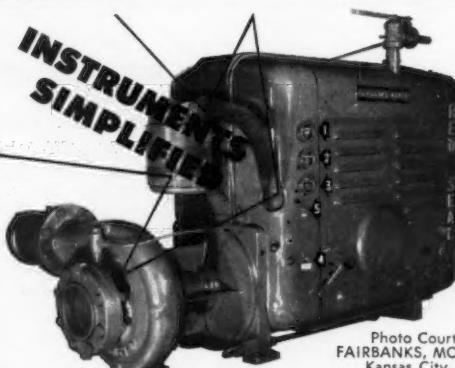


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FAIRBANKS, MORSE & CO.  
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All the instruments needed on an engine powered irrigation pump — NO DUPLICATIONS!

**MURPHY INSTRUMENTS ARE SIMPLE,  
ACCESSIBLE, NEAT.**

1. Water Temperature Gauge — Switch.
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3. Water Pressure Gauge — Switch.
4. Magnetic Ignition Switch (for battery ignition and Diesel).
5. Stop Switch.

Exclusive design micrometer contact adjustments\* "stay put." Exclusive lockout\* on pressure gauge-switches for full automatic sequence in starting.

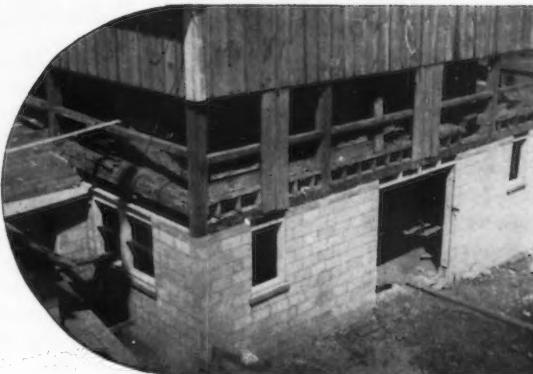
**WRITE FOR INFORMATION**

Wherever there is irrigation, you will find a Murphy Dealer with a stock of switches and parts, ready to offer you service.

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Manufacturer  
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## Add new life to old buildings by remodeling with CONCRETE

Agricultural engineers can help farmers add years of usefulness to their old farm houses, barns, machine sheds, hog houses and other buildings by remodeling and modernizing them with concrete foundations, walls and floors or asbestos-cement siding and firesafe roofs. Such remodeling improves sanitation, reduces maintenance and increases resistance to rats, rot, storms, termites and fire. The buildings acquire increased efficiency and new life.

Designing such farm improvements presents both a challenge and an opportunity to agricultural engineers. They must utilize much of the old structures and yet create sturdy, economical buildings.

Concrete's firesafety makes it the logical choice for farm remodeling. And its economy makes it a wise investment. First cost is moderate, upkeep is low, service life long. That adds up to **low-annual-cost** construction that soon pays for itself in terms of feed and labor saved, improved sanitation, enhanced livestock health and easier, cleaner and more comfortable living for the farmer and his family.

## PORTLAND CEMENT ASSOCIATION

33 West Grand Avenue, Chicago 10, Illinois

A national organization to improve and extend the uses of portland cement and concrete... through scientific research and engineering field work

## Index to Advertisers

American Bosch Corp.	636	Kaiser Aluminum & Chemical Corp.	687
American Chain & Cable Co., Automotive and Aircraft Div.	686	Kohler Co.	704
American Spring & Wire Specialty Co.	702	Link-Belt Co.	647, 679
Armco Steel Corp.	637	Lycoming-Spencer Div., Avco Mfg. Corp.	642
Audit Bureau of Circulations	701	Mechanics Universal Joint Div., Borg-Warner Corp.	633
Bearings Co. of America	641	New Departure, Div. of General Motors	3rd cover
Bendix Aviation Corp.	629	New Holland Machine Co.	697
Blood Brothers Machine Div., Rockwell Spring & Axle Co.	625	New Idea Farm Equipment Co.	699
Bower Roller Bearing Co.	644	The New York Air Brake Co.	690
J. I. Case Co.	2nd cover	The Oliver Corp.	695
Chain Belt Co.	689	Portland Cement Assn.	703
Char-Lynn Co.	703	Purolator Products, Inc.	688
Chicago Rawhide Mfg. Co.	632	Rochester Manufacturing Co.	628
Clark Equipment Co.	645	Russell, Burdsall & Ward Bolt & Nut Co.	635
Crucible Steel Co. of America, Agricultural Sales Div.	648	Stow Mfg. Co.	694
Dayton Rubber Co.	630	The Texas Co.	691
Deere & Company	685	The Texas Foundries	693
Durkee-Atwood Co.	683	The Timken Roller Bearing Co.	4th cover
Electric Wheel Co.	700	The Torrington Co.	639
Fafnir Bearing Co.	681	Unitcast Corp.	696
Frank W. Murphy, Manufacturer	703	U. S. Steel Corp.	640
Hydrex Div., The New York Air Brake Co.	690	Veeder-Root, Inc.	646
International Harvester Co.	627	Warner Automotive Parts Div., Borg-Warner Corp.	638
International Nickel Co.	692	Wisconsin Motor Corp.	698
		Young Radiator Co.	634

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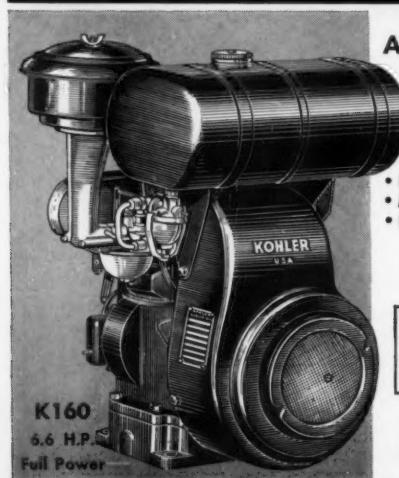
with Asiatic and tropical American experience of over 40 years. At present professor of tropical agriculture, University of Miami, Miami, Fla.  
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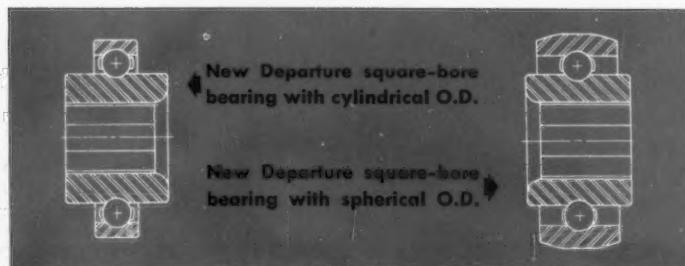
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# FACTS

about

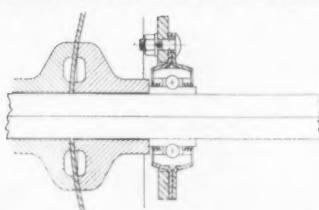
**NEW DEPARTURE**

BALL BEARINGS

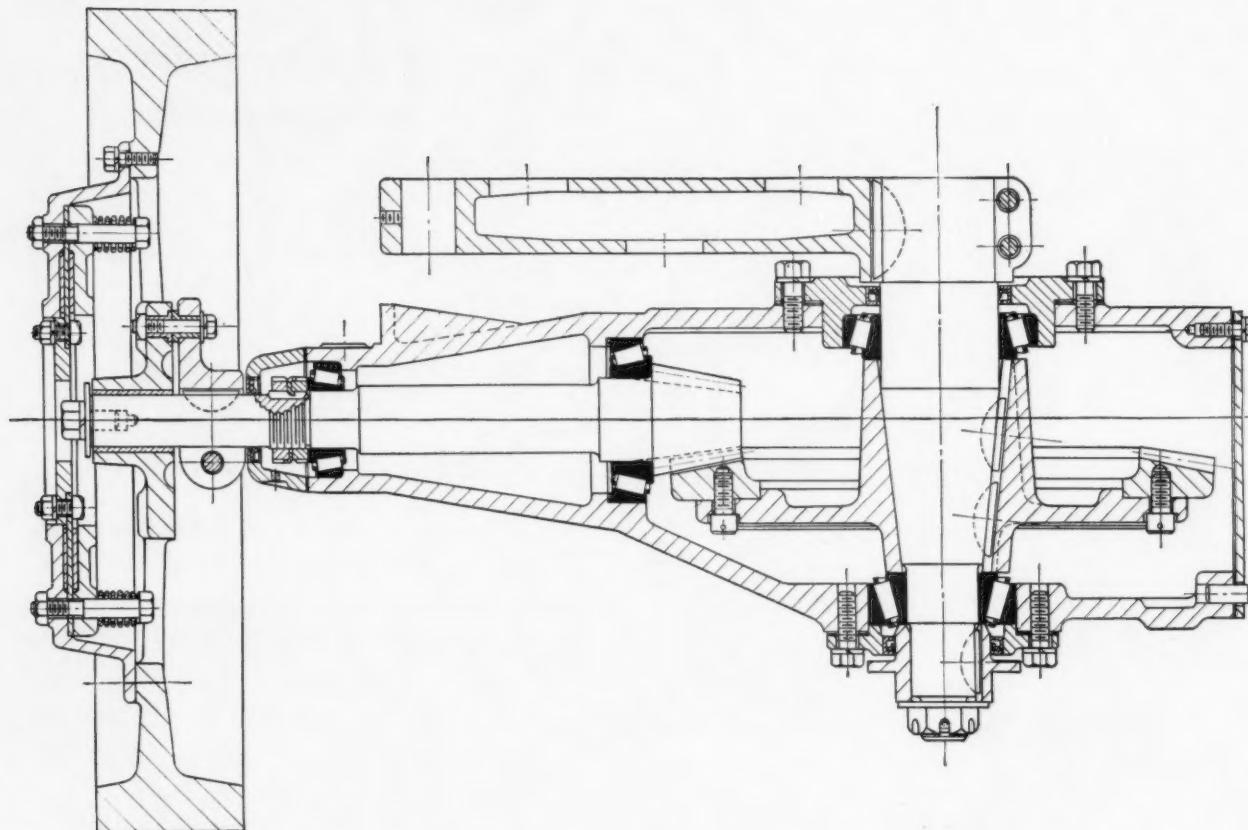


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ONE of the interesting design problems in Oliver's hay baler was the gear box. The bevel gears put heavy radial, thrust and combination loads on their shafts. It takes rugged bearings to meet this condition.

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Timken bearings help solve three of the agricultural engineer's big problems: combination loads, dirt, ease of operation. They keep shafts concentric with housings which makes closures more effective, keeps dirt out of bearings. They reduce friction to a minimum, make equipment operate more smoothly and easily. They assure longer equipment life, less chance of breakdowns in the field.

Write today for your free copy of "Tapered Roller Bearing Practice in Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

*The farmer's assurance  
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